August 25, 2008
Miami-Dade Pedestrian Safety Project: Phase II
FINAL IMPLEMENTATION REPORT AND EXECUTIVE SUMMARY

Pedestrian Safety Engineering and Intelligent Transportation
System-Based Countermeasures Program for Reduced Pedestrian Fatalities,
Injuries, Conflicts and Other Surrogate Measures: Miami-Dade Site

Prepared for

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CHAPTER 1 EXECUTIVE SUMMARY AND INTRODUCTION

1.1 PURPOSE, GOALS, AND SCOPE

Purpose

This report presents the methods and key findings from the Miami-Dade comprehensive pedestrian safety planning and engineering project. It is one of three such projects in the nation funded by the Federal Highway Administration (FHWA) to evaluate:

In Phase I: The effectiveness of a pedestrian safety plan to target higher-injury areas;

In Phase II: The implementation of a range of mostly low-to-moderate-cost, innovative engineering safety improvements.

This report concentrates on the Phase II countermeasure implementation efforts, minimizing duplication with earlier reports, and focusing primarily on the implementation experience and overall lessons learned.

Goals

This project had three primary goals:

1.) The installation of pedestrian countermeasures;

2.) The scientific evaluation of the countermeasures in order to determine their efficacy; and

3.) To produce a significant crash reduction along the treated high crash corridors.

Key Work Products

The University of Florida, Department of Civil and Coastal Engineering and Miami-Dade County Department of Public Works proposed and conducted the project from planning through implementation. A separate Phase I (Planning) Final Report, finalized Dec 5, 2002, covered:

- **Problem Identification**: a comprehensive picture of pedestrian injury collisions in high crash corridors in Miami-Dade County.
- **Countermeasure Selection Plan**: a conceptual blueprint, describing proposed countermeasures for Pedestrian Safety implementation, and descriptions of countermeasures selected for inclusion in the Pedestrian Safety study.

- **Evaluation Plan**: a conceptual plan for assessing the impacts of the countermeasures.

- **Outreach and Awareness Plan**: a conceptual plan for educating the public about countermeasures to be implemented, in addition to promoting safer driver and pedestrian behavior.

The June 25, 2004 Phase II Research Implementation Plan clarified the countermeasure plan, including cost estimates and, where appropriate, conceptual layout plans. It also presented refined outreach and data collection/evaluation plans. Due to engineering and institutional challenges, some of the proposed countermeasures could not be implemented while additional countermeasures were added. These challenges are described in this report.

1.2 MIAMI-DADE SETTING

1.2.1 Crash Demographics in Miami-Dade County

This section of the executive summary provides a brief overview of the presentation in the Phase 1 Report, which is not repeated in the main portion of this report. This section has been added to the executive summary to give the reader perspective on the nature of the crash problem in Miami-Dade County, how treatment corridors were selected, and how countermeasures were selected and matched to each selected corridor. Miami-Dade had a population of 2,253,362 in 2000, which is about 14 percent of Florida's total population. The population is diverse and predominantly Hispanic (57.3 percent). The per capita pedestrian fatality and injury crash rates are very high. Among the 82 pedestrian deaths in 1999, nearly half involved pedestrians age 55 or older. Total injuries are greatest in number for ages 25 through 54. African Americans are over- represented in terms of population with a crash rate approximately 50 percent higher than their proportion of the population, and Hispanic Americans are under represented with a rate less than half their proportion of the population. Alcohol use in pedestrian fatalities is under-represented in Miami-Dade at only 16.8 percent, compared to 35 percent statewide.

A little more than half of the pedestrian crashes in Miami-Dade County occurred on state or county roads, while 46 percent of the remaining crashes occurred on local roads. Because there are many more miles of local roads than state or county roads, the pedestrian crash rate per mile is much higher for this type of roadway. The number of pedestrian fatalities was approximately equal for local, state and county roads reflecting a much higher fatal crash rate per mile for state and county roads. In regard to lighting conditions, children and seniors are more likely to be struck in daylight than pedestrians of other ages, and pedestrians age 18 to 24 have the highest incidence of nighttime collisions.

The major pedestrian safety effort completed outside of the pedestrians safety project was a National Highway Traffic Safety Administration (NHTSA) project that focused on enforcement in Miami Beach and city wide public education aimed at drivers and pedestrians (Zegeer et. al, 2008). The NHTSA project was implemented between 2002 and 2004. The Engineering components of the FHWA project were installed in 2005 and 2006. This presence of the NHTSA effort provided an excellent opportunity to determine the effects of engineering treatments added to city and community wide outreach and education efforts.

The NHTSA effort included the following components:

- Pedestrian safety message mounted in bus and Metrorail train posters;
- Public awareness announcements about pedestrian safety broadcasted on city and county access channels in Spanish and English and on selected Spanish speaking radio stations;
- Walk Safely pedestrian brochures distributed to the Miami-Dade School Board, hospital and medical department, public library, police departments and elected officials' offices;
- Pedestrian safety workshops for older pedestrians.
- Walking Through the Years: Pedestrian Safety for Older Adults. Booklets were delivered to organizations such as the Miami-Dade school Board, hospital and medical departments, retirement homes, public libraries (similar materials were distributed in Spanish);
- Pedestrian enforcement of driver yielding behavior during 2002. Police stopped 2006 drivers for failing to yield to pedestrians.

Miami-Dade County has the highest incidence of pedestrian injuries and fatalities in the State of Florida, which ranked within the top two states in number of pedestrian crashes as well as per capita pedestrian crashes during the baseline period. In recent years the pedestrian crash rate had remained relatively steady prior to the implementation of the NHTSA and FHWA Pedestrian projects. During the nine years prior to the FHWA project there were a total of 15,472 pedestrian crashes in the DHSMV Miami-Dade County, which included 670 fatal crashes (4.2 percent). Figure 1.1 shows the geographic distribution of pedestrian crashes during the baseline period as a crash density map. High crash zones are represented by darker colors. Figure 1.2 shows the Crash map for South Miami Beach. South Miami Beach has the highest crash density in Miami-Dade County.

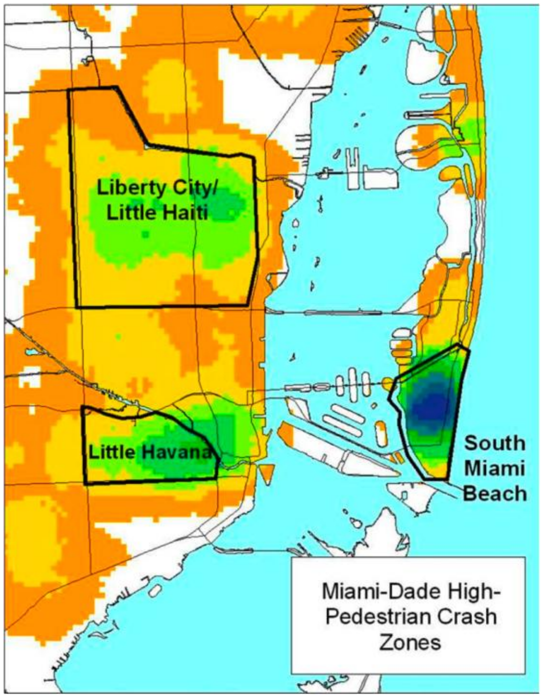

Figure 1.1 Miami-Dade High Pedestrian Crash Zones

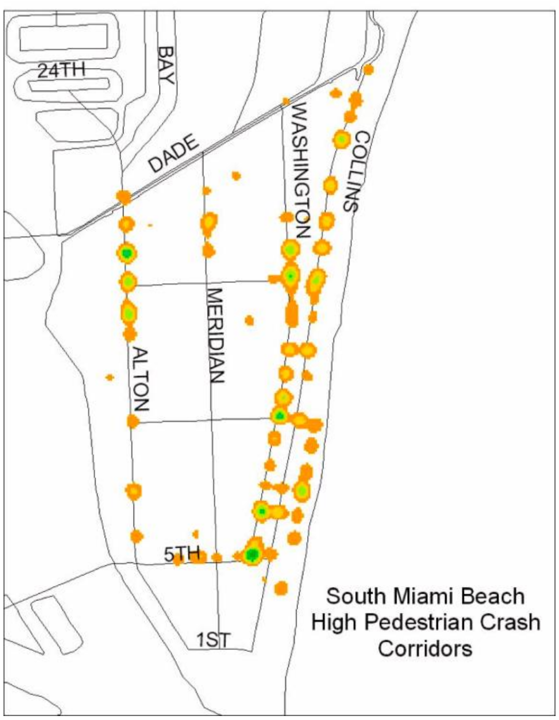

Figure 1.2 South Beach High Pedestrian Crash Corridors

1.3 PROJECT OVERVIEW AND SCHEDULE

The Phase 1 planning analysis and recommendations were developed in 2002 and the plan was revised in 2004. A zonal approach was employed to identify crash corridors with dense clustering of serious pedestrian crashes. Crash data over a five-year period were first mapped using GIS software to determine high crash corridors that were associated with the majority of serious crashes. The following process was followed to identify these high crash corridors. First, pedestrian crash data were extracted from Florida DMV records. Second, these crashes were entered into a GIS database and plotted. Third, crashes were weighted for severity and a crash index assigned. Fourth, the Pedestrian and Bicycle Crash Analysis Tool (PBCAT) was applied to all crashes and these data were merged back onto the GIS database. Fifth, the research team including an FDOT and Miami-Dade County representative visited each high crash corridor identified in steps one through four with a spreadsheet in hand documenting all pedestrian crash activity in that zone to examine local features contributing to crashes. Sixth, data were desegregated for specific aspects of the crash. Seventh, surrogate data were recorded or crash reports were studied where required to resolve ambiguities.

The outreach plan proposed integrating selected countermeasure and outreach and awareness into ongoing efforts, as well as working with agencies responsible for pedestrian safety (e.g., Police and Public Health departments) and working with grassroots community groups committed to pedestrian safety projects. For the most part, pedestrians did not need education about countermeasures because their meaning was intuitively clear (e.g., countdown signals and push buttons that confirm a button press). The media plan employed in Miami-Dade County involved a continuation of the NHTSA campaign described above through the office of the Pedestrian Bicycle Coordinator.

A two-day site visit in 2003 by FHWA staff and consultants included a detailed review of the initial countermeasure plan. In 2004 the project team fine tuned the work plan and proceeded into Phase II implementation. Extensive engineering efforts began in early in 2005 and continued into 2006. An Implementation Plan and Preliminary Engineering Report provided a detailed blueprint for conducting Phase II. The actual implementation was predominantly consistent with the Phase I report and the Phase II implementation plans, although some modifications were made in response to practical difficulties or changing exigencies.

1.4 COUNTERMEASURE OVERVIEW

A total of fifteen countermeasures (nine general engineering countermeasures and six intelligent transportation systems [ITS] countermeasures) were implemented by the University of Florida team during this Phase II investigation:

GENERAL ENGINEERING COUNTERMEASURES

1. Reducing the minimum green time at mid-block crosswalks controlled by a traffic signal.
2. Advance yield markings at crosswalks with an uncontrolled approach.
3. Recessed or offset stop lines for intersections with traffic signals.
4. Leading pedestrian intervals (LPI)
5. Pedestrian push buttons that confirm press
6. "Turning Vehicles Yield to Pedestrians" symbol signs for drivers
7. Eliminate permissive left turns at a signalized intersection.
8. In-street pedestrian signs
9. Pedestrian zone signs
10. Midblock traffic signal

INTELLIGENT TRANSPORTATION SYSTEMS (ITS) COUNTERMEASURES

1. ITS video pedestrian detection
2. Rectangular LED rapid flash beacons for uncontrolled multilane crosswalks
3. ITS smart lighting at crosswalks with nighttime crashes
4. ITS "No Right Turn on Red" (NRTOR) Signs
5. Pedestrian countdown timers
6. Speed trailers.

In addition, an outreach program was implemented by Miami-Dade County through the office of the pedestrian bicycle coordinator. This outreach effort included distribution of a video public service announcement (PSA) to cable and small/ethnic local TV stations, and presentations at schools and senior centers. It was not possible to evaluate each of the outreach efforts separately.

1.4.1 Comparison of Countermeasures: Cost

The overall cost of this project was slightly greater than $1,000,000 dollars, including $870,540 in federal funding, $140,000 in state funding, and $186,771 in county funding. The federal funding averaged roughly $ 217,635 per year.

The total costs of the nearly seven-year-long project included the following estimated cost breakdown:

PLANNING PHASE I:	$125,000
IMPLEMENTATION PHASE II:	$1,010,540
Including:	
Design of Countermeasures:	$133,933
Installation/Deployment Labor:	$108,833
Materials and Equipment:	$302,913
Data Collection & Evaluation:	$282,172
Other Program Management	$182,690

(Including planning and design of countermeasures not installed)

In general, the labor costs exceeded the equipment and materials costs. Overall, the engineering/administrative costs were quite substantial, largely due to the need for specialized training, mobilization, and approvals for new devices. These engineering/administrative costs often exceeded the material/equipment costs and the installation labor.

The least expensive countermeasures in total per-unit costs were Pedestrian Warning Signs. The most expensive countermeasure was the Video Detection System.

1.4.2 Comparison of Countermeasures Availability and Standard Use:

All but two countermeasures were compliant with the Manual of Uniform Traffic Control Devices. The rectangular rapid flash beacon and the “turning vehicles yield to pedestrians” symbol signs were granted FHWA permission to experiment. Several of the treatments that were considered experimental when initially proposed by the University of Florida team were added to the MUTCD in the 2003 revision.

1.4.3 Comparison of Countermeasures: Installation Complexity

Countermeasures that required the least effort to install were:

- Countdown Pedestrian Signals. The original incandescent signals were simply changed out.
- Pedestrian push buttons that confirmed the button press. These were easily swapped for the standard push button.
- Advance Stop/Yield Lines. These were easily installed along the corridor with new pavement. They were no more difficult to install than lines at the minimum distance. Moving stop lines involve greater cost because the old markings need to be removed by grinding.
- Reducing Minimum Green Time at midblock traffic signals. These only required timing changes in the traffic signals computer.
- Leading Pedestrian Interval. These only required timing changes in the traffic computer.

Countermeasures that required a moderate effort to install were:

- “Turning Vehicles Yield to Pedestrians” Symbol Signs. These signs needed to be mounted on the mast arm.
- In-Street “Yield to Pedestrians” Signs. These signs needed to be installed in the roadway and had to be frequently replaced.
- Rectangular LED Rapid Flashing Beacons. These signs communicated by RF transmitters and were powered by a solar array. Therefore they required no wiring.
- ITS Smart Lighting. This treatment was part of the Rectangular LED Rapid Flashing Beacon treatment.
- Speed Trailer. The major issue with speed trailers is labor associated with attending to the trailer. Newer solar power speed signs that can be affixed to poles would be easier to install.
- ITS “No Right Turn on Red” Signals. These signs required installation on the mast arm.

Countermeasures that required the most effort to install were:

- Eliminate Permissive Left Turns at Signals. This treatment required replacing the traffic signal array.
- ITS Video Pedestrian Detection. This treatment required installation and adjustments to get it to work correctly.

- Installation of a midblock signal. This is a relative high cost item including mast arm and wiring. Originally installed to evaluate midblock animated eyes display later converted to a short minimum green midblock installation.

1.6 DEVICES NOT INSTALLED

Several devices originally proposed in the Phase II work plan were not implemented for the reasons provided below.

1.6.1 ITS Midblock Signals with Animated Eyes

The animated eyes countdown signals were not installed as originally planned, because the vendor, Relume, lost interest in supporting experimentation with the device, apparently after assessing the market potential for the devices. Ordinary Countdown timers were installed in their place.

1.6.2 ITS Midblock Pedestrian Signal with Animated Eyes

The midblock crossing with animated eyes display showing the direction the pedestrian was crossing was not installed because research carried out under FHWA permission to experiment in St. Petersburg, Florida found the rectangular LED rapid flashing beacon to be more effective. The rectangular LED rapid flashing beacon was subsequently added to the implementation plan and the original midblock crossing proposed for installation of the animated eyes display was converted to a standard midblock traffic signal.

1.7 DATA COLLECTION AND ANALYSIS METHODS FOR PEDESTRIAN SAFETY COUNTERMEASURES

The most important measure was data on crashes because these best validated the safety value of the countermeasures installed. However, because multiple treatments were installed in all corridors it was impossible to attribute the crash reductions to any particular countermeasure. We originally planned on employing a mix of video recording and field observation to record surrogate measures. Unfortunately the video recording systems were destroyed by a major hurricane. This forced the team to substitute field observation for video recording to assess the effects of each treatment on surrogate measure at all of our sites. The shift from video to live data recording required the team to reduce the number of items scored from those originally proposed because field observation does not allow multiple viewing of events (a necessary condition to reliably score many aspects of a single event).

The pedestrian/driver observations employed a mixture of design features. Some experiments were simple before and after installation evaluations. In other cases, multiple baseline (staged introduction of the treatment at different sites to control for extraneous variables) and follow-up observations were conducted to ascertain the effects of the passage of time and novelty fading. In a few cases treatments were introduced, removed and reintroduced using replication logic to rule out the effects of uncontrolled variables. Statistical tests were employed (generally z-tests and t-tests) to test for difference of proportions/means.

1.8 SUMMARY OF EXPERIMENTAL RESULTS FOR PEDESTRIAN SAFETY COUNTERMEASURES

Following is a summary of results obtained for each countermeasure. This table indicates the purpose for installing each countermeasure, highlighted results, and a ranking of relative cost. Results are only reported in this table if they are statistically significant ($p<0.05$).

Table 1.1 Results Obtained for Each Countermeasure

COUNTER-MEASURE	PURPOSE	OBSERVATION HIGHLIGHTS	RELATIVE COST
Push buttons that confirm press	To Confirm press so pedestrian waits for WALK	The percentage of cycles that a pedestrian pressed the button increased from 33.8% to 58.1% at the first site and from 40.3% to 54.3% at the second site. The percentage of pedestrians who pressed the button that waited for the "WALK" increased from 51.2% to 72.5% at the first site and from 72.3% to 86% at the second site.	Low Cost
Reduce Minimum Green Time	To reduce pedestrian wait time to increase pedestrian compliance	Reducing minimum green time reduced pedestrian wait time and significantly increased pedestrian compliance. At one site reducing minimum green time improved pedestrian compliance from 64% to 98%. Vehicle delay also increased	Low Cost
Video Pedestrian Detection	To place calls for pedestrian that don't press the call button	The device was reliable but many pedestrians did not wait even when the device placed the call for them. This treatment needs to be used in conjunction with reduced minimum green time	High Cost
Lead Pedestrian Phase	To provide a head start for pedestrians. When RTOR is permitted, the maximum effect is obtained with left turning vehicles	This treatment produced an increased yielding by drivers of left turning vehicles	Low Cost

“Turning Vehicle Yield to Pedestrians" symbol sign	To increase yielding by drivers of turning vehicles	Mixed results. This sign was not superior to the text only sign	Moderate Cost
Electronic NRTOR sign	To restrict right turns on red during the WALK and yellow phase	This sign statistically significantly reduced violations as compared to the static sign and produced a marked decrease in the percentage of drivers turning ROR who made no stop from 40% to coming to 13%.	Moderate Cost
Countdown Pedestrian Signals	Provides information to pedestrian on the time remaining to cross	The installation of the countdown timers was associated with a statistically significant increase in the percentage of pedestrians that pressed the call button	Low Cost
In-Street "Yield to Pedestrian Signs"	This sign marks crosswalks and reminds drivers of their obligation to yield right-of-way to pedestrians in crosswalks	These signs increased the percentage of drivers yielding right-of-way to pedestrians from 19% to 71% but they were easily damaged	Moderate Cost
Pedestrian Zone Signs	To warn drivers to expect pedestrians in the roadway	This sign had no effect on driver speed	Low Cost
Speed Trailers	To alert drivers to slow down	The speed trailer increased braking for pedestrians but had no effect on speed which was already within the speed limit	Moderate Cost
Rectangular LED Rapid Flashing Beacons	Alerts drivers that a pedestrian is in the crosswalk	This sign increased the percentage of drivers yielding to pedestrians from 0% to 65% at one site and from 1% to 92% at the second site. Both test sites were high-speed multilane roads.	Moderate Cost
Dynamic Lighting	Alerts driver that a pedestrian is crossing and makes the pedestrian more visible	This device was used with the rectangular LED beacon. It was not effective but the level of illumination was not very great	Moderate Cost
Eliminate Permissive Left Turn	Reduces conflicts between left turning vehicles and pedestrians	This treatment reduced conflicts between left turning vehicles and pedestrians	High Cost

Advance Yield Markings	This treatment can increase the visibility of pedestrians in crosswalks	The wrong size sign was specified in the 2003 MUTCD NOT EVALUATED IN THIS STUDY	Low Cost
Offset Stop Lines	This treatment can increase the visibility of pedestrians in crosswalks	NOT EVALUATED IN THIS STUDY	Low Cost

1.9 CRASH DATA ANALYSIS

The introduction of the NHTSA project was associated with a modest reduction in crashes. Adding the engineering countermeasure produced a further reduction in crashes at all sites. Following is a summary table showing the mean number of crashes per year at each treated site and for all treated sites combined during each condition of the study.

Table 1-2 Numbers of Crashes per Year at Treated Sites

SITE	BASELINE PERIOD CRASHES PER YEAR	NHTSA STUDY PERIOD CRASHES PER YEAR	FHWA STUDY PERIOD CRASHES PER YEAR
All sites combined	101	87	51
Alton Road: (5th St. to 17th St.)	13.8	10	8.5
5 St: (Alton Rd. to Ocean Dr.)	6.5	4.6	4
Collins Ave: (5th St. to 24th St.)	18.8	20	13
41 St: (Alton Rd to Pine Tree Dr.)	7	5.3	2
Collins Ave & Harding Av	14.3	13	9.5
NE 6th Ave. (NE 141 St. to NE 151 St.)	7.7	8	3
NE 163 St. (NW Ave. to Biscayne Blvd)	25.8	20.7	8

1.10 EDUCATION AND OUTREACH

All of the traffic control devices deployed in this study were intuitive in nature and required little outreach and awareness training. Countdown pedestrian signals, offset stop lines, push buttons that confirm the button press, automatic pedestrian detectors (passive in nature), a leading pedestrian phase, "Turning Vehicles Yield to Pedestrian" signs, in roadway signs, elimination of permissive left turns, dynamic NTOR signs, the rectangular LED rapid flashing beacon, dynamic lighting (passive in nature), pedestrian zone warning signs, shorter minimum green waiting times, and advance yield markings are familiar to motorists and pedestrians. Therefore outreach and awareness focused on continued enforcement along with a continuation of the educational countermeasures deployed as part of the National Highway Traffic Safety Administration (NHSTA) Miami-Dade Contract that begun prior to the FHWA Cooperative Agreement.

1.11 PHASE II CONCLUSIONS

1.11.1 Lessons Learned: Overall Project Success and Countermeasures

In terms of the project goals the project was successful. Many treatments were implemented in the high crash areas. Miami-Dade County was impressed with some of the countermeasures and is presently in the process of deploying more of them in other areas. Some examples are countdown pedestrian signals and rectangular LED rapid flashing beacons. We also were successful in learning a good deal about some of the countermeasures including how to use them most effectively. We have published four papers in Transportation Research Record on our findings to date. More papers will be submitted this year. We also obtained a statistically significant reduction in crashes at the treatment sites.

1.11.2 Utility of Crash Typing Tools in Selecting Treatments

The GIS crash mapping tools were particularly useful and were further enhanced by the MPO adding demographic information to the field, such as ages, PBCAT information, driver ages, time of day, weather conditions, etc. Sorting this information by site and printing it in booklet form made this information immediately available during site visits. However, there were times when only the crash reports could sort out the nature of a particular problem. The crash diagram was one of the most useful components of the crash report in determining the type of crash. On the other hand, the PBCAT tool that was available during baseline assessment had several limitations that reduced its utility. In order of usefulness, the enhanced GIS crash maps were the most useful tool, followed by site visits conducted with the booklet that sorted crashes by sites and listed all of the information added to the GIS database, followed by the crash reports. It is hoped that the most recent version of PBCAT will prove more useful to practitioners wishing to match countermeasures to crash sites.

1.11.3 Problems That Needed to be Overcome

There is a good deal of coordination required to make a large project successful. One problem we had not anticipated was extreme weather. Miami-Dade County was struck by two major hurricanes while we were assessing the treatments we installed. The storms destroyed camera placement sites, requiring us to shift to field observers for some of our evaluations. Storm damage also required us to reinstall some treatment installations, and the extent of damage tied up contractors for long periods of time, resulting in delays in installing some of the equipment we needed to make evaluations. At other times other priorities, such as changing the signage for all school crossings in Miami-Dade County, resulted in delays in implementing particular countermeasures.

Anther issue was the sheer scope of such a project. Agencies wishing to implement engineering countermeasures along high crash corridors might wish to prioritize the zones identified in their initial analysis and determine and implement treatments one zone at a time. This would allow better coordination and use of resources without overburdening administration and infrastructure. It would also allow the agency to assemble the contracting resources to implement the project more easily.

One positive feature was the excellent level of cooperation from Miami-Dade County and the Florida Department of Transportation District Office. The professionals from these organizations provided constructive suggestions and did not present barriers to innovation. We also received excellent cooperation from the Miami-Dade Metropolitan Planning Organization. The bicycle pedestrian coordinator and the signals design engineer were particularly helpful in assisting the team with its mandate.

CHAPTER 2 COUNTERMEASURE IMPLEMENTATION

This chapter discusses the deployment of the countermeasures that includes an overview of each countermeasure along with any problems that needed to be addressed in the installation process. Also presented is a comparison of the countermeasures in terms of cost and device availability. A description of each individual countermeasure, its purpose, the setting for each Miami-Dade installation, and approval status, and relative cost information, are presented in Chapter 3.

2.1 OVERVIEW OF INSTALLATION CHALLENGES

Phase II involved the installation and evaluation of a broad range of pedestrian safety measures, from nearly routine signal timing changes to customized video detection equipment.

However, there were several common challenges that the Miami-Dade team faced:

- Selection and Confirmation of Countermeasures: The initial process of selecting countermeasures and assigning them to specific locations was described in the Phase I Final Report and the Phase II Implementation Plan and Preliminary Engineering Report. This involved development of a comprehensive list of candidate countermeasures, which were then rated on several criteria, such as match to the crash type, cost, presumed efficacy, and ease of implementation. These were matched to each location by meticulous analysis of the type of crash, causal factors and the physical characteristics of the roadway. For example, if vehicles turning right on red injured a number of pedestrians at a particular location, a static NRTOR sign and an electronic NRTOR sign were considered. Because a “NO TURN ON RED WHEN PEDESTRIANS ARE PRESENT” sign was already present we decided to compare the standard “NO RIGHT TURN ON RED” sign with the electronic NRTOR sign. We also placed a premium on low cost items that could be installed in large numbers to increase the chance of producing a sufficiently large reduction in crashes to be detected.

- Scheduling of Countermeasures: We attempted to install countermeasures in a staged manner (multiple baseline design) in order to control for extraneous variables. Although we were usually successful in following the dictates of the selected design protocol, there were times when treatments would not be introduced or removed according to our schedule because of conflicting priorities of the Contractor or Miami-Dade staff. In these instances, we often needed to collect fresh baseline data to allow for a valid comparison. This problem arose often and contributed to the increased cost of the research component of this project.

- Extreme Weather Events: Two major hurricanes struck Miami-Dade during the critical period when countermeasures were being installed and evaluated. These storms destroyed the video recording systems, forcing the team to employ field observation. One implication of this change was the need to reduce the number of items recorded in order to ensure the collection of reliably data. The storms also destroyed some countermeasure, which had to be reinstalled. These storms added additional cost to the project.

2.2 COMPARISON OF COUNTERMEASURES: EASE OF IMPLEMENTATION

Three countermeasures proved more challenging to deploy:

- The Electronic NRTOR sign;
- The Video Pedestrian Detector;
- In Street Yield to Pedestrian signs; and

The first listed two devices involved procurement or deployment of electronic equipment that engineering staff and electricians were not highly familiar with. The remaining device was easily deployed but would not stay deployed due to frequent collisions with vehicles.

The manufacturer installed the Rectangular LED Rapid Flashing Beacons greatly reducing the scope for installation problems with this relatively new technology.

2.3 COMPARISON OF COUNTERMEASURES: COSTS

The overall cost of this project was slightly greater than 1 million dollars, including $870,540 in federal funding, $140,000 in state funding, and $186,771 in county funding. The federal funding averaged roughly $ 217,635 per year.

The total costs of the nearly seven-year-long project included the following rough estimates:

PLANNING PHASE I:	$125,000.
IMPLEMENTATION PHASE II:	$1,010,540.
Including:	
Design of Countermeasures:	$133,933.
Installation/Deployment Labor:	$108,833.

Materials and Equipment: $302,913

Data Collection & Evaluation: $282,172

Other Program Management $182,690

(Including planning and design of countermeasures not installed)

In general, the labor costs far exceeded the equipment and materials costs. Overall, the engineering/administrative costs were quite substantial, largely due to the need for specialized training, mobilization, and approvals for new devices. These engineering/administrative costs often exceeded the material/equipment costs and the installation labor.

The least expensive countermeasures in total per-unit costs were Pedestrian Warning Signs. The most expensive countermeasure was the Video Detection System.

If this project is replicated by a community with a strict focus on improving pedestrian safety with know treatments in a cost-effective manner, the data collection/evaluation and other program management costs could be substantially lower than the costs of the present study. Cost estimates are provided for each item in Chapter 3. Table 2.1 shows an estimate of capital costs and labor plus engineering costs for each countermeasure.

Table 2.1 Capital Cost and Labor/Engineering Costs for Each Countermeasure

COUNTERMEASURE	Estimated Cost Per Unit	Estimated Installation-Engineering Cost/Unit	Operations/Maintenance Needs and Other Notes
Push buttons that confirm press	$105	$535	Low level of maintenance required
Video Pedestrian Detection	$14,250	$8,500	No information on long-term maintenance. Adjusted by manufacturer
"Turning Vehicle Yield to Pedestrians" symbol sign	$25	$55	Low level of maintenance required
Electronic NRTOR sign	$3000	$700	Seemed to work well. Use of this sign is increasing
Countdown Pedestrian Signals	$435	$45	Easy to retrofit. Easy to maintain. We had no issues with this device

In-Street "Yield to Pedestrian Signs"	$225	$50	High level of damage if not on raised island. We had no raised island locations
Pedestrian Zone Signs	$25	$45	Low level of maintenance required
Speed Trailers	$25/day	$55	Worked well in Miami because of solar output
Rectangular LED Rapid Flashing Beacons	$9,000	Included in Equipment Pricing	Installed by contractor. Required some changes to battery box because of flooding. System redesigned. Handled by warranty.
Dynamic Lighting	$600	Included in Equipment Pricing	Was not very bright. Difficulty aiming it where needed
Eliminate Permissive Left Turn	$2500	$1500	May require change in signal head
Advance Yield Markings	$50	$150	Material has a long lifetime.
Offset Stop Lines	$50	$150	Material has a long lifetime. No grinding needed when installed on fresh pavement.

In general, the labor and engineering costs often exceeded the materials/equipment costs. As is often the case the engineering/administrative costs for products used for the first time, tend to be higher than for equipment that are routinely installed. As staff becomes more familiar with new technology there is a major savings in time and effort. Additionally, installation cost were high because only a few devices could be installed at a time, rather than installing all devices in one operation.

2.4 COMPARISON OF COUNTERMEASURES: AVAILABILITY AND STANDARD USE

All but two countermeasures were compliant with the Federal Manual on Uniform Traffic Control Devices (MUTCD). It was necessary to obtain special approval to experiment with the rectangular LED rapid flashing beacon and the “Turning Vehicles Yield to Pedestrians” symbol signs. Several countermeasures considered experimental when initially proposed by the Miami-Dade team were added to the MUTCD in the 2003 revision. One other countermeasure requiring approval (in street pedestrian turning vehicle yield signs at signalized intersections) was removed after engineering studies revealed there was insufficient room to install these signs at the Miami Beach intersections originally selected for evaluation.

CHAPTER 3 DEPLOYMENT OF INDIVIDUAL COUNTERMEASURES

This chapter discusses the full deployment of countermeasures. Because of the large number of countermeasures installed, data collection and evaluation were only conducted at selected locations.

3.1 PEDESTRIAN PUSH BUTTON THAT CONFIRMS PRESS

Purpose and Description

This treatment consists of a pedestrian stainless steel push button with a piezo driven solid state switch that provides two types of feedback when the push button is pressed. First, the button is illuminated with a 1200 mcd red light emitting diodes (LED) for 0.1 s (Momentary LED Model) and second, a 2.6 kHz tone is sounded simultaneously with the LED flash when the button was pressed and a 2.3kHz tone was sounded when the button was released. The device could also be modified so the light remained on until the onset of the "WALK" indication. These buttons were installed at 17 intersections, typically with 2 buttons per intersection.

Figure 3.1 Picture of Pedestrian Push Button That Confirms Press

Notes: It was difficult to see the LED light in bright Florida sunlight. It appeared that the auditory feedback was more critical to the efficacy of the device. In areas with less bright sunlight the pilot light might be more salient. These buttons might also be of useful to visually impaired pedestrians because they confirm the button press. However, accessible call buttons with a locator tone would be preferred when taking into account the needs of visually impaired pedestrians.

Table 3.1 Push the Button Confirming Press: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
Alton Rd. & 15th St.	East-West Crosswalks	4	1
Alton Rd & 16th St.	East-West Crosswalks	4	1
Alton Rd & 17th St.	East-West South leg only	2	1
Alton Rd. & 6th St.	East-West Crosswalks	4	1
Alton Rd. & 8th St.	East-West Crosswalks	4	1
5th St. & Collins Ave.	North-South on East leg only	2	2
5th St. & Meridian Ave.	North-South Crosswalks	4	2
41st. St & Chase Ave.	North-South Crosswalks	4	7
41st. St. & Royal Palm Ave.	North-South Crosswalks	4	7
41st. St. & Pine Tree Drive	North-South Crosswalks	4	7
NE 163rd St. & 8th Ave.	North-South Crosswalks	4	10
NE 163rd St. & 12th Ave.	North-South Crosswalks	4	10
900 N. Miami Beach Blvd	2 Midblock Crosswalks	4	10
NE 163rd St. & 15th Ave.	North-South Crosswalks	4	10
NE 163rd St. & 19th Ave.	North-South Crosswalks	4	10
NE 6th Ave. & 167th St.	East-West Crosswalks	4	11
NE 6th Ave. & 149th St.	East-West Crosswalks	4	11
		64	

Federal Approval Status (MUTCD)

This pedestrian safety measure had federal approval status according to the Manual on Uniform Traffic Control Devices (MUTCD) when they were purchased.

Cost

The cost for each pedestrian push button was $105.00. The installation cost was $40.00 per call button for a total cost of $145.00 per installed button.

Availability

This product can be purchased off the shelf.

How/Who Installed

This device was installed by changing out existing push buttons that did not provide feedback when pressed. The project contractor installed this countermeasure.

Utility/Environmental Issues

None

Installation Challenges

This device was easy to install. There were no challenges.

Maintenance Needs

These devices seem reliable and durable and are associated with minimal maintenance needs. Because these push buttons provide feedback when they are pressed we observed fewer multiple presses, which could extend the life of the buttons, reducing maintenance costs over conventional buttons.

3.2 DECREASE MINIMUM GREEN TIME

Purpose and Description

This treatment was installed at mid-block traffic signals. It required the signal to be operated in isolation mode (non synchronous timing). The minimum green time was reduced to decrease pedestrian wait time and increase compliance with the signal. Three of these treatments were installed as indicated in table nine. Prior to the start of the study both signals were run in synchronous mode, and the cycle length was 130 s between 8 am and 8 pm at the Alton Road crosswalk and varied from 90 s to 120 s at the crosswalk on SW 8th Street. Minimum green time was evaluated at 30 s, 1 minute and 2 minutes at both crosswalks. The speed limits at these locations were 35 mph on Alton Rd. and 30 mph on SW 8th St.

Figure 3.2 Picture of Midblock Crossing with Reduced Minimum Green Time

Table 3.2 Decrease Minimum Green: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
Alton Midblock between 14th St. and 14th Court	Minimum green time was reduced to 1 minute.	1	1
Midblock at 1300 8th	Minimum green time was reduced to 1 minute.	2	outside zones
Midblock Crosswalk at Barry College	Minimum green time was reduced to 30 s.	2	outside zones
NE 5th St. East of NE 1st Ave.*	North and South side of crosswalk	1	outside zones
		6	

* Note that city installed midblock crosswalk at this site.

Notes: This treatment markedly improved pedestrian compliance, and greatly reduced pedestrian wait time; however, switching from synchronous to isolated mode with a short minimum green time increased motorist delay. Therefore this treatment would be most likely to be installed in communities that value pedestrian flow or at sites where the trade-off between pedestrian delay and safety balanced the increase in vehicle delay.

Federal Approval Status (MUTCD)

The signal timing changes made to deploy this treatment were in compliance with the MUTCD.

Cost

There are no hard costs associated with the deployment of this countermeasure. However, the installation of this countermeasure at NE 5th St. East of NE 1st Ave. includes the cost of installing the midblock signal.

Availability

This only requires signal-timing changes. It is relatively easier to deploy if it can be done on a central traffic signal computer rather than making the changes at the signal cabinet.

How/Who Installed

The Miami-Dade signals engineer and his staff deployed this countermeasure.

Utility/Environmental Issues

None

Installation Challenges

This countermeasure was easy to deploy. There were no challenges.

Maintenance Needs

There are no maintenance requirements associated with this countermeasure.

3.3 VIDEO PEDESTRIAN DETECTION

Purpose and Description

This device uses video detection technology to detect the pedestrian and put in a call for a mid-block traffic signal. An Autoscope Solo Pro was used for pedestrian detection in this study. The processor was included in the camera. The camera sent compressed video via twisted pair. Two rectangular zones were set up on the sidewalk approaching the curb; the pedestrian had to cross both zones to trigger the device. The device could determine direction of movement by the order in which the zones were crossed. With this method the pedestrian only put in a call when entering the crosswalk. This system was installed at one midblock traffic signal on Alton Road.

Figure 3.3 Picture of Device Used For Pedestrian Detection

Table 3.3 Video Pedestrian Detection: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
Alton Midblock between 14th St. and 14th Court	East Side	1	1
Alton Midblock between 14th St. and 14th Court	West Side	1	1
		2	

Notes: This device was reasonably reliable in detecting pedestrians but it did not detect joggers that ran into the intersection and cyclists that rode into the intersection. It did not put in false calls.

Federal Approval Status (MUTCD)

This pedestrian safety measure does not require special approval.

Cost

The cost for the complete video detection system was $14,250. The installation cost was $6252. to install the complete system.

Availability

This product can be purchased off the shelf.

How/Who Installed

Our contractor mounted this device on the mast arm pole. The manufacture assisted us in defining the departure rectangles and ensuring that the device worked correctly.

Utility/Environmental Issues

None

Installation Challenges

It would have been more difficult to install the device without the assistance of the manufacturer.

Maintenance Needs

They are unknown; however, it is likely that these devices should prove as reliable at similar devices currently used to detect vehicles.

3.4 LEAD PEDESTRIAN PHASE

Purpose and Description

The purpose of this device was to give a head start for pedestrians over left and right turning vehicles at the start of the WALK. Pedestrians crossing the main line receive a 4 second exclusive pedestrian phase while all vehicle signals remained in the all red phase. These vehicles lost 4 seconds of green time in order to give the pedestrians a 4 second exclusive pedestrian phase. This treatment provides the best protection from vehicles turning left and provides less protection from vehicles turning right because they may still turn right on red.

Figure 3.4 Picture of Leading Pedestrian Phase

Notes: This treatment was effective at increasing yielding by drivers turning left but was not effective at improving the behavior of drivers turning right. Prohibiting right turn on red at the start of the WALK when a pedestrian pushed the call button should greatly improve the efficacy of this countermeasure.

Table 3.4 Lead Pedestrian Phase: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
Alton Rd. & 16th St.	Applied to intersection phasing. North & South legs	1	1
Alton Rd. & 6th St.	Applied to intersection phasing. North & South legs	1	1
Alton Rd. & 8th St.	Applied to intersection phasing. North & South legs	1	1
Collins Ave. & 15th St.	Applied to intersection phasing. North & South legs	1	5
Collins Ave. & Lincoln Rd.	Applied to intersection phasing. North & South legs	1	5
		5	

Federal Approval Status (MUTCD)

The signal timing changes made to deploy this treatment were in compliance with the MUTCD.

Cost

There were no hard costs associated with the deployment of this countermeasure.

Availability

This treatment only requires signal-timing changes. It is relatively easier to deploy if it can be done on a central traffic signal computer rather than making the changes at the signal cabinet.

How/Who Installed

The Miami-Dade signals engineer and his staff deployed this countermeasure.

Utility/Environmental Issues

None

Installation Challenges

This countermeasure was easy to deploy. There were no challenges.

Maintenance Needs

There are no maintenance requirements associated with this countermeasure.

3.5 "TURNING VEHICLES YIELD TO PEDESTRIANS" SYMBOL SIGN

Purpose and Description

This treatment was a symbol version of the "Turning vehicles must yield to pedestrians" text sign. This sign retained the text message "Turning vehicles" and "to" and substituted the yield symbol for the word "yield" and the pedestrian symbol for the word "pedestrian". The purpose of using this sign in place of the text message sign was to make the sign more comprehensible to tourists that were not native speakers of English and to increase recognition distance.

Figure 3.5 Picture of "Turning Vehicles Yield to Pedestrians" Symbol Sign

Table 3.5 "Turning Vehicles Yield to Pedestrians" Symbols Sign: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
Alton Rd. & 16th St.	Facing minor street, E & W approaches	2	1
5th St. & Collins Ave.	All approaches	4	2
5th St. & Jefferson Ave.	Facing minor street, N & S approaches	2	2
5th St. & Meridian Ave.	All approaches	4	2
5th St. & Michigan Ave.	Facing minor street, N & S approaches	2	2
5th St. & Washington Ave.	All approaches	4	2
Collins Ave. & 11th St.	Facing minor street, E & W approaches	2	5
Collins Ave. & 14th St.	Facing minor street, E & W approaches	2	5
Collins Ave. & 16th St.	All approaches	3	5
Collins Ave. & 17th St.	W & N approaches only	2	5
Collins Ave. & 21st St.	All approaches	4	5
Collins Ave. & 41st St	W & N approaches only	2	6
Indian Creek & 41st St.	Facing minor street, E & W approaches	2	6
Collins Ave. & 75th St.	On N & W approaches	2	8
Harding Ave. & 75th St.	North-South on East leg only	2	8
Indian Creek & 65th St.	On E & S approaches	2	8
Normandy Dr. & Bay Dr.	On N & S approaches	2	8
NE 163rd St. & 19th Ave.	On S & W approaches	2	10
NE 167th St, & NE 8th Ave.	All approaches	4	10
		49	

Notes: This treatment was effective at increasing yielding at one site but ineffective at the other site.

Federal Approval Status (MUTCD)

This sign was tested under FHWA permission to experiment.

Cost

The cost for each sign was $25.00. The installation cost was $55.00 per sign for a total cost of $80.00 per installed sign.

Availability

Any sign shop can prepare this sign.

How/Who Installed

Our contractor mounted this device on the mast arm pole.

Utility/Environmental Issues

None

Installation Challenges

There were no installation challenges involved in installing these signs. However deployment did require traffic control and the use of a truck with a mechanical arm to install the device on the mast arm.

Maintenance Needs

There are no maintenance requirements associated with this countermeasure.

3.6 ELECTRONIC “NO RIGHT TURN ON RED” (NRTOR) SIGN

Purpose and Description

This sign was illuminated when right turn on red was not permitted. The sign was installed on the mast arm in the same location that the static “No turn on red when pedestrians in crosswalk” sign and the “No turn on red” sign were installed. This allowed a direct comparison of all three signs.

Figure 3.6 Picture of Electronic No Turn on Red Sign

Notes: The electronic NRTOR sign reduced the percentage of motorists turning right-on-red when a pedestrian was present over that produced by the two static signs and reduced the percentage of conflicts between vehicles turning right on red and pedestrians crossing within the crosswalk over the other two signs. However there were many violators during all conditions. The electronic sign had an even larger effect on increasing the percentage of violators coming to a complete stop before turning right-on-red and almost eliminated free flow right-on-red turns that are most dangerous to pedestrians.

Table 3.6 Electronic “No Turn on Red” Sign: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
41st. St. & Pine Tree Dr.	Facing North bound traffic	1	7
		1	

Cost

The cost for this sign was $3000.

Availability

These signs are available off the shelf. They need to be installed with a utility truck with an arm and bucket. These signs also have to be wired into the controller system.

How/Who Installed

Miami-Dade County installed this sign on the mast arm pole.

Utility/Environmental Issues

None

Installation Challenges

There were no installation challenges involved in deploying this sign. However deployment did require traffic control and the use of a truck with a mechanical arm to install the device on the mast arm.

Maintenance Needs

There were no maintenance requirements associated with this countermeasure. However this sign will eventually need to be replaced or serviced after the service life of the lights has expired.

3.7 PEDESTRIAN COUNTDOWN SIGNALS

Purpose and Description

This treatment was a countdown pedestrian signal that displayed a walking person symbol during the "WALK" indication, counted down the seconds in the clearance phase along with the flashing hand display, and displayed the solid hand during The "DON’T WALK" indication which began during the all red phase. These signals were programmed to begin the countdown at the start of the pedestrian clearance (flashing hand) phase and counted down to 0 at the end of the yellow phase.

Figure 3.7 Picture of a Pedestrian Countdown Signal

Notes: The countdown displays decreased the percentage of pedestrian in the crosswalk during the all red phase and were associated with an increase in the percentage of pedestrians that pressed the call button as well as the percentage of pedestrians that pressed the call button that then waited for the WALK indication.

Federal Approval Status (MUTCD)
This pedestrian safety measure has federal approval status according to the Manual on Uniform Traffic Control Devices (MUTCD).

Cost
The cost for each call button was $495.00. The installation cost was $45.00 per call button for a total cost of $540.00 per installed button.

Availability
This product can be purchased off the shelf.

How/Who Installed
This device was installed by changing out existing incandescent pedestrian signals that did not provide a countdown feature. The project contractor installed these devices.

Utility/Environmental Issues
None

Table 3.7 Pedestrian Countdown Signals: Deployment Locations Listed by Corridor

`	Installation	Qty	Corridor
Alton Rd. & 8th St.	North & South legs	4	1
Alton Rd. & 15th St.	All legs	8	1
Alton Rd. & Lincoln Rd.	All legs	8	1
Alton Rd. & 16th St.	All legs	8	1
Alton Rd. & 17th St.	East, West & South legs	6	1
41st. St. & Alton Rd.	All directions	8	7
41st. St. & Chase Ave.	South, East & West legs	6	7
41st. St. & Royal Palm Ave.	All directions	8	7
163rd St. & 12th Ave.	East & West legs	4	10
163rd St. & 15th Ave.	All legs	8	10
163rd St & 18th Ave.	all legs	8	10
163rd St. & 19th Ave.	East & West legs	4	10
163rd St. & West Dixie Hwy	East & West legs	4	10
NE 167th St. & NE 2nd Ave.	East & West legs	4	10
NE 167th St. & NE 6th Ave.	All legs	8	10
NE 6th Ave & NE 145th St.	North & South legs	4	11
NE 6th Ave & NE 149th St.	North & South legs	4	11
		104	

Installation Challenges

These devices were easy to install. There were no challenges.

Maintenance Needs

These devices seem reliable and durable and are associated with minimal maintenance needs. They will eventually be replaced at the end of the LEDs lifetime.

3.8 "IN-STREET YIELD TO PEDESTRIANS SIGNS"

Purpose and Description

In-Street Pedestrian Signs are intended for use at uncontrolled (not signalized) crosswalks to remind drivers of laws regarding pedestrians' right-of-way. They are more noticeable than roadside signs and may also exert a minor traffic-calming effect by effectively narrowing the inside lanes slightly. Dimensions and color: 12" x 44", fluorescent yellow green diamond sheeting with 10" x 24" white high intensity sheeting inserts. Overall height is 47 inches. The signs can be installed with either a portable or fixed base.

Figure 3.8 Picture of In-street "Yield to Pedestrians" Signs

Notes: These signs were effective but had a very short lifespan. The streets were narrow and did not have a median island to protect the signs. We found that using three signs on each approach was no more effective than using one.

Table 3.8 In-street "Yield to Pedestrians" Signs: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
Collins Ave. @ 6th St.	These signs were placed facing North and South approaches	2	5
Collins Ave. @ 9th St.	These signs were be placed facing North and South approaches	2	5
Collins Ave. @ NE 13th St.	These signs were be placed facing North and South approaches	2	5
		6	

Federal Approval Status (MUTCD)

This pedestrian safety measure has federal approval status according to the Manual on Uniform Traffic Control Devices (MUTCD) Section 2B.12, IN STREET PEDESTRIAN CROSSING SIGN (R1-6, R16a). The legend "State Law" may be shown at the top of the sign if applicable. The legends "Stop For" or "Yield To" may be used in conjunction with the appropriate symbol. If a median island is available, the in-street pedestrian crossing sign, if used, should be placed on the island.

Cost
The cost for each sign was $225.00. The installation cost was $50.00 per sign for a total cost of $275.00 per installed sign.

Availability
This product can be purchased off the shelf.

How/Who Installed
Our contractor installed these devices.

Utility/Environmental Issues
These signs were not durable enough to use on narrow roads with many large trucks making turning movements.

Installation Challenges
The primary challenge was maintaining the signs.

Maintenance Needs
The maintenance cost for these signs was excessive. The rectangular rapid flash beacon may be a more durable installation at these locations.

3.9 PEDESTRIANS ZONE SIGNS

Purpose and Description
MUTCD R1-6 signs may be used along with a plaque indicating the distance that pedestrians may be expected.

Table 3.9 Pedestrian Zone Signs: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
Collins Ave. @ 75th St.	Pedestrian Crossing warning signs installed 30 ft North of Northernmost crosswalk facing Northbound traffic	1	8
Harding Ave. @ 75th St.	Pedestrian Crossing warning signs installed 30 ft South of Southernmost crosswalk facing Southbound traffic	1	8
NE 6th Ave. @ NE 141st St.	Pedestrian Crossing warning signs installed 30 ft North of Northernmost crosswalk facing Northbound traffic and 30 ft South of Southernmost crosswalk facing Southbound traffic	2	11
NE 6th Ave. @ NE 142nd Ave.	Pedestrian Crossing warning signs installed 30 ft North of Northernmost crosswalk facing Northbound traffic and 30 ft South of Southernmost crosswalk facing Southbound traffic	2	11
NE 6th Ave. @ NE 145th St.	Pedestrian Crossing warning signs installed 30 ft North of Northernmost crosswalk facing Northbound traffic and 30 ft South of Southernmost crosswalk facing Southbound traffic	2	11
NE 6th Ave. @ NE 149th St.	Pedestrian Crossing warning signs installed 30 ft South of crosswalk facing Southbound traffic	1	11
Collins Ave. & 16th St.	Pedestrian Crossing warning signs installed 30 ft South of crosswalk facing Southbound traffic	1	5
Collins Ave. & 14th St.	Pedestrian Crossing warning signs installed 30 ft South of Southernmost crosswalk facing Southbound traffic	1	5
		11	

Notes: These signs had no effect on driver speed. It is unclear whether they contributed to the reduced level of crashes observed in this study.

Federal Approval Status (MUTCD)
This pedestrian safety measure has federal approval status according to the Manual on Uniform Traffic Control Devices (MUTCD).

Cost
The cost for each sign was $25. The installation cost was $45. per sign for a total cost of $70. per installed sign.

Availability
This product can be purchased off the shelf.

How/Who Installed
Our contractor installed these devices.

Utility/Environmental Issues
There were no issues.

Installation Challenges
There were no installation challenges.

Maintenance Needs
Signs are durable with a long lifetime unless struck by a vehicle.

3.10 SPEED TRAILERS

Purpose and Description
Portable Changeable Message Speed Limit Signs, also known as “radar speed trailers,” are used to deter speeding. These devices can be installed along the side of the road; typically in parking areas, and display the speed of each approaching vehicle and can flash LEDs when the approaching vehicle is speeding. A speed limit sign is included on the trailer. Above a user-selected maximum, the sign “blanks out” to avoid enticing drivers into exhibitions of speed. A computer within the device recorded speed data.

Figure 3.9 Picture of a Speed Trailer

Notes: These signs reduced braking for pedestrians but had little effect on vehicle speed. One reason why the sign was ineffective in reducing vehicle speed was most vehicles were already driving within the speed limit.

Table 3.10 Speed Trailers: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
Collins Ave. @ 32nd St.	ITS Speed Trailer placed midblock before intersection	1	6
Collins Ave. @ 36th St.	ITS Speed Trailer placed midblock before intersection	1	6
Collins Ave. @ 72nd St.	ITS Speed Trailer placed midblock before intersection	1	8
		3	

Federal Approval Status (MUTCD)

Changeable speed limit signs are approved in MUTCD Section 2B.13, Speed Limit Sign (R2-1): "A changeable message sign that displays to approaching drivers the speed at which they are traveling may be installed in conjunction with a Speed Limit sign." According to MUTCD guidelines "If a changeable message sign displaying approach speeds is installed, the legend YOUR SPEED XX km/h (MPH) or such similar legend should be shown. The color of the changeable message legend should be a yellow legend on a black background or the reverse of these colors."

For signs typically used on roadways with 45 MPH & greater speed limits the MUTCD specifies sign dimensions of 36 by 48 inch (18 inch high digits).

For neighborhoods and school zones, the MUTCD specifies that the absolute minimum sign size allowed is 24 x 30 inches (12" high digits), and it provides for larger dimensions in increments of six inches "where speed, volume, or other factors result in conditions where increased emphasis, improved recognition, or increased legibility would be desirable" [2003 MUTCD 2B.03].

Cost
The speed trailers were furnished by the City of Miami Beach.
The estimated cost for each trailer was $25 per day. The estimated installation cost was $45 per trailer.

Availability
This product can be purchased off the shelf.

How/Who Installed
Speed trailers were loaned to the project by the City of Miami Beach.

Utility/Environmental Issues
No significant issues.

Installation Challenges
Speed trailers are common equipment items with municipal and law enforcement organizations.

Maintenance Needs
The primary maintenance issue was moving the signs. There is sufficient sunlight in Miami to ensure the signs remained charged.

3.11 RECTANGULAR LED RAPID FLASHING BEACONS

Purpose and Description
This treatment was the standard pedestrian warning sign with two LED flashers attached (see Figure 1). The LED flashers were each 6 inches wide and 2.5 inches high placed 9 inches apart. Each unit was dual indicated (LED's on front and back). Each side of the LED beacon flashed in a wig-wag flashing sequence (left, then right) the 2 large LED's in combination flashed 76 times in the wig-wag flashing sequence during a 30 second cycle. Of the 2 large LED's, the Left LED, flashed 2 times (in a slower type of a rapid flash) each time it was energized followed by the Right LED, which flashed in a very fast rapid 3 flash volley when energized. The total number of flashes in this combination was 190 total flashes per 30 second cycle. Four signs along with beacons were installed at each crosswalk. The devices were linked by radio frequency transponders so a depression of any of the pedestrian call buttons immediately activated the flashers on all four signs. At the South Bayshore Drive crosswalk a sign was placed on the left side of each approach and on the right side of each approach at the median island. At the NW 67th Street site a sign along with beacons was placed on the left side of each approach and on the right side at a median just after the crosswalk on the northbound approach and before the

crosswalk on the southbound approach. A LED facing the pedestrian flashed to indicate to pedestrians that the system was operating. The system also presented an audible message instructing pedestrians that the light flashing across the street indicates that the device was operating, and instructing them to wait for cars to stop before crossing. Signal duration was timed assuming a crossing speed of 3.5 feet per second.

Figure 3.10 Picture of Rectangular LED Rapid Flashing Beacons

Table 3.11 Rectangular LED Rapid Flashing Beacons: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
NW 67th St. @ Main Street	North and South Approaches on roadside and on median	4	Outside zones
South Bayshore Drive @ Darwin	North and South Approaches on roadside and on median	4	Outside zones
S.W. Avenue @ S.W. 163rd St..	Both Approaches	2	Outside zones
Ponce De Leon @ Soaraz Ave.	Both Approaches	2	Outside zones
		12	

Notes: These signs produced large increases in the percentage of motorists yielding to pedestrians on multilane roads.

Federal Approval Status (MUTCD)

This device was installed in accordance with permission to experiment granted by FHWA to FDOT.

Cost

The cost for each sign installed sign unit was $15,000. The installation cost was included with the sign cost. The overall cost was $150,000.00 for these units. The cost was higher for the Miami-Dade units because they required ornamental units that conformed with the surroundings.

Availability

This product can be purchased off the shelf.

How/Who Installed

The vendor installed these devices. Because the vendor installed these devices, there were no installation issues.

Utility/Environmental Issues

No significant issues.

Installation Challenges

Because the device relies upon radio frequency communication to link the devices, there is no need to install wiring under the roadway. Because the device is solar powered there is no need to connect power to the unit.

Maintenance Needs

These devices seem very reliable. The primary maintenance issue would be the repair or replacement of a unit if a vehicle strikes it.

3.12 DYNAMIC LIGHTING

Purpose and Description

This treatment was used in conjunction with the rectangular LED rapid flashing beacons treatment described above. When a pedestrian pressed the call button to activate the beacon at night, the device was activated and LED white lighting illuminated the departure portion of the curb face and the first 4 feet of the crosswalk. This dynamic pad lighting consisted of four 2.5 by 1.25 inch housings each containing 3 LEDs.

Figure 3.11 Picture of Dynamic Lighting

Table 3.12 Dynamic lighting: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
NW 67th St. @ Main Street	North and South Approaches on roadside and on median	4	Outside zones
South Bayshore Drive @ Darwin	North and South Approaches on roadside and on median	4	Outside zones
S.W. Avenue @ S.W. 163rd St..	Both Approaches	2	Outside zones
Ponce De Leon @ Soaraz Ave.	Both Approaches	2	Outside zones
		12	

Notes: The LED lighting was not very bright compared with the rectangular rapid flashing beacon. There activation did not increase yielding above the level obtained with the beacons system alone.

Cost

The cost for the lighting feature was included in the price of the beacons. A switch was installed to allow researchers to turn the lighting feature on and off to evaluate its efficacy.

Availability

These signs are available off the shelf. However, they do require permission to experiment at this time.

How/Who Installed

The vendor installed this device.

Utility/Environmental Issues

None were noted.

Installation Challenges

Because geometric features influence the location of the beacon system, in some cases the lighting did not fully illuminate the departure area of the crosswalk.

Maintenance Needs

There were no maintenance requirements associated with this countermeasure. However, the unit will eventually need to be replaced after the service life of the unit has expired.

3.13 NO PERMISIVE LEFT TURN

Purpose and Description

This treatment involved reconfiguring the signal heads to eliminate permissive left turns.

Notes: This treatment reduced conflicts between pedestrians and left turning vehicles. However many drivers violated the red immediately following the end of the protected left turn phase. It may be better to use a lagging left turn phase with this treatment.

Table 3.13 Eliminate permissive Left Turn: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
41st St. & Pine Tree	East and West Direction	2	7
		2	

Cost

The cost for the signal change was $4,000.

Availability

The hardware needed to make this change is readily available.

How/Who Installed

Miami-Dade County made the changes to the signal head and made the signal phase changes.

Utility/Environmental Issues

None

Installation Challenges

There were no installation challenges involved in making this change.

Maintenance Needs

This change does not have a significant impact on maintenance of the traffic signal.

3.14 OFFSET STOP LINES

Purpose and Description

This treatment involved installing stop bars 20 feet in advance of the crosswalk rather than the minimum distance of 4 feet in advance of the crosswalk. Studies have shown that offset and setback stop bars can reduce vehicle/pedestrian conflicts. Setting back stop bars has also been shown to add .75 s to intersection clearance time and can reduce turning vehicle threats by increasing intersection visibility.

Figure 3.12 Picture of Offset Yield Lines

Notes: This treatment is easier to install on fresh pavement.

Table 3.14 Offset Stop Lines: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
167th St. & 2nd Ave.	All approaches to intersection	4	10
168th St. & 6th Ave.	All approaches to intersection	4	10
169th St. & 8th Ave.	All approaches to intersection	4	10
170th St. & 12th Ave	All approaches to intersection	4	10
171st. St. & 15th Ave	All approaches to intersection	4	10
172nd St. & 16th Ave.	All approaches to intersection	4	10
173rd St. & 17th Ave	All approaches to intersection	4	10
174th St. & 19th Ave.	All approaches to intersection	4	10
175th St. & W. Dixie Highway	All approaches to intersection	4	10
		36	

Cost

The cost to put down thermoplastic lines was $200.

Availability

This item is readily available.

How/Who Installed

Florida Department of Transportation installed the advance stop lines.

Utility/Environmental Issues

None

Installation Challenges

There were no installation challenges involved in deploying this counter measure.

Maintenance Needs

Moving the stop bar has do significant impact on maintenance of the markings.

3.15 ADVANCE YIELD MARKINGS

Purpose and Description

Advance yielding markings may be installed in advance of crosswalks at uncontrolled locations. Previous work has shown that advance yield markings placed 30 feet in advance of the crosswalk increases the distance that drivers yield in advance of the crosswalk. Advance yield markings were only installed at one site because the sign size specified in the 2003 manual was much smaller than the sign used in the research that supported the introduction of this marking into the manual.

Figure 3.13 Picture of Advance Yield Markings

Notes: This treatment is designed to reduce multiple threat conflicts and therefore has been installed at the two multilane locations with the rectangular LED rapid flash beacon.

Table 3.15 Eliminate Permissive Left Turn: Deployment Locations Listed by Corridor

Location	Installation	Qty	Corridor
Collins Ave @ 7th St.	These signs and markings were placed on he North and South Approaches	1	5
		1	

Cost

The cost for installing these markings was $200 each.

Availability

This item is available off the shelf.

How/Who Installed

Markings were installed by our Contractor on Collins @ 7th and by Miami-Dade County at the Miami Lakes and Coconut Grove rectangular LED rapid flash beacon sites.

Utility/Environmental Issues

None

Installation Challenges

It was not possible to get approval for the correct sign size. This issue will be resolved in the next version of the MUTCD.

Maintenance Needs

This marking does not have a significant impact on maintenance costs.

CHAPTER 4 DATA ANALYSIS FOR PARTICULAR INDIVIDUAL COUNTERMEASURES

Figure 4.1 Picture of Data Collectors

4.1 INDIVIDUAL TREATMENT RESULTS

This chapter summarizes data collected for each countermeasure. Data were only collected at sample locations if a large number of a particular countermeasure was installed. When data were collected at multiple sites, care was taken to ensure that multiple treatments were not introduced at the same time. When new information was learned about a specific countermeasure, the study was submitted for publication. References are provided if the results of the study were published in a peer-reviewed journal.

Although treatments were introduced along corridors, we decided to categorize treatments results by treatment rather than corridor because treatments were frequently implemented across corridors to better control for generalization across sites. For example, one installation of push buttons that confirmed the press would be installed in one corridor while another installation of push buttons that confirmed the press would be installed in a second corridor. This would require presenting the study twice or presenting half the data in the report for one zone's report and presenting the other half of the data in the report on the second zone's report. Instead we thought it best to keep the sites together for each experiment sorted by the type of application.

We also felt that crash data should parallel the zone headings because the focus of the collective treatments in each corridor was to reduce crashes in that corridor and because all countermeasures in each corridor work together to reduce crashes in that corridor. Therefore, we have treated crash data by corridor in the next section of this chapter.

4.1.1 Push Button That Confirms Press

Many pedestrian crashes involve pedestrians crossing during the "DON'T WALK" pedestrian signal. The purpose of this study was to evaluate the effects of push buttons that provide visual and audible feedback when pressed on: 1.) The proportion of cycles that a pedestrian pressed the call button; and 2.) the proportion of pedestrians pressing the call button that waited for the "WALK" sign. Data were collected at two busy intersections in Miami Beach with relatively high daily traffic flows. The installation of push buttons that provided visual and audible feedback when pressed was associated with a statistically significant increase in the percentage of cycles that pedestrians pressed the button, as well as a significant increase in the percentage of pedestrians pressing the button that waited for the "WALK" sign before crossing. Because behavior only changed when the new push buttons were installed and the push buttons were installed at a different point in time at each site, it was possible to rule out potential confounding variables such as weather, traffic flow and changes in the demographic characteristics of the pedestrian. The percentage of pedestrians crossing against the signal also decreased at both locations after the new push buttons were installed as did the percentage of pedestrians trapped in the middle of the road when crossing. Because push buttons that emit a visible and audible cue when they are pressed are relatively inexpensive, this treatment is a relatively cost effective way to increase the percentage of pedestrians who press the button and wait for the ‘Walk” sign before crossing. Accessible push buttons also acknowledge when they have been pressed. These data show that accessible buttons may benefit all pedestrians. The results of this intervention are summarized in Table 4.1. (These results were published in Transportation Research Record No. 1982 (Van Houten, Ellis, Sanda and Kim, 2006).

Table 4.1 Results of Push Button Intervention

41st & Pine Tree Dr.	Baseline	Treatment	Z score	p-value
Number of Cycles When a Pedestrian was present who could press the button	420	570		
% of cycles button pressed	33.8	58.1	7.673	0.01
% pedestrian that pressed button waited for WALK	51.2	72.5	4.91	0.01
% cycles pedestrian trapped	3.8	3.1	0.56	NS
% cycles ped vehicle conflicts	Very rare event			
Total of Pedestrians Crossing (includes those not pressing button	879	1044		
% of all pedestrian violating signal	70.4	52.6	8.17	0.01

Alton & 16th St.	Baseline	Treatment	Z score	p-value
Number of Cycles When a Pedestrian was present who could press the button	600	810		
% of cycles button pressed	41.83	54.2	4.633	0.01
% pedestrian that pressed button waited for WALK	82.09	85.93	1.937	0.05
% cycles pedestrian trapped	4.7	2.4	2.293	0.025
% cycles ped vehicle conflicts	Very rare event			
Total of Pedestrians Crossing (includes those not pressing button	1577	2490		
% pedestrian violations	59.7	51.7	5.086	0.01

4.1.2 The Effects of Varying Minimum Green Time

Pedestrians often do not wait for the "WALK" sign at signal-controlled mid-block crossings. Many factors may contribute to this phenomenon, but one variable could be wait time. It is likely that the major reason people try to cross against the signal at mid-block signal-controlled crosswalks, when there are gaps in traffic in the first half of the roadway, is the length of the average wait time for the WALK sign. It is common to have minimum green times of a minute or more on a main line at a signal-controlled mid-block crosswalk. If a pedestrian arrives early in the cycle they may become frustrated and attempt to cross a street in the presence of fast heavy traffic. The purpose of this study was to determine the effect of wait time on pedestrian signal compliance at two mid-block crosswalks in Miami-Dade County. One crosswalk traversed an arterial multilane road with two-way traffic and the second crosswalk traversed a multilane road with one-way traffic. At both crosswalks minimum green time was varied between 30 seconds and 120 seconds. The results indicated that pedestrian compliance decreased as minimum green time was increased and that compliance dropped more rapidly as minimum green time was increased at the location with the lower Average Daily Traffic counts (ADT) and one-way traffic. Data also showed that the percent of pedestrians trapped at the centerline increased with increased minimum green time. The results of this intervention are summarized in Table 4.2. These results were published in Transportation Research Record No. 2002 (Van Houten, Ellis and Kim, 2007).

4.1.3 Video Pedestrian Detection

Pedestrians often consistently push the call button for the "WALK" sign at signal-controlled mid-block crossings. Many factors may contribute to this phenomenon, but one variable could be previous experience with long wait times. Another factor could be detection of a gap for the first half of the crosswalk after arrival at the crosswalk. This practice could lead to the pedestrians being trapped in the center of the roadway, and in the absence of a median a trapped pedestrian may select an inadequate gap for the second half of the crossing in their haste to get out of the roadway. If these pedestrians had pressed the call button, the signal may have changed while they were still trapped in the middle of the crossing, thereby affording some protection crossing the final half of the roadway. The purpose of this study was to determine whether video detection increases the percentage of pedestrian protected by the signal while crossing the second half of the crosswalk. The results indicated the treatment had a small but significant positive effect. The results of the Video Pedestrian Detection treatment are provided in Table 4.3.

Table 4.2 Results of Varying Minimum Green Time Intervention

Mid Block Alton Rd.	30 sec	1 min	2 min
Number of Cycles When a Pedestrian was present who could press the button	150	600	840
% pedestrian that pressed button waited for WALK	98	85	64
Z Score (p) Waited for WALK		7.78 (.01)	18.38 (.01)
% cycles ped vehicle conflicts	Very rare event		
% cycles pedestrian trapped	0	19	23
Z Score (p) Pedestrians Trapped		11.86 (.01)	15.84 (.01)
Pedestrian Delay in s	15	37	47
Z Score (p) for Pedestrian Delay		Z=6.25 (0.01)	Z=12.287 (.01)
N (Vehicle Delay in seconds)	641 (15)	2094 (7.525)	5960 (5.062)
Z Score (p) value for Vehicle Delay		4.91 (0.01)	6.91 (0.01)
Mid Block 1300 SW 18th St.	30 sec	1 min	2 min
Number of Cycles When a Pedestrian was present who could press the button	270	90	840
% pedestrian that pressed button waited for WALK	82%	65%	61%
Z Score (p) Waited for WALK		4.49 (.01)	5.92 (.01)
% cycles ped vehicle conflicts	Very rare event		
% cycles pedestrian trapped	Not relevant (one-way traffic)		
Pedestrian Delay	13.7	18	30
Z Score (p) for Pedestrian Delay		Z-0.9333 (.05	Z-6.2148 (.01)
N (Vehicle Delay in seconds)	Data was not obtained		
Z Score (p) value for Vehicle Delay	Data was not obtained		

Table 4.3 Results of Video Detection Intervention

MOEs	Before	After	Statistic
Total Number of pedestrians crossing	752	485	
% pedestrians pressing call button	42.89	36.36	two sample t test p = 0.3554
% pedestrian crossing during WALK	49.48	47.58	two sample t test p = 0.957
% of times video detector places a false call		0	
% of times Video detector fails to a call when ped present		0	
% of pedestrians completing crossing entire crosswalk during WALK	43.8	50.5	z test for proportions 1.625 not sig
% of peds crossing 2nd half of crosswalk during WALK	51.3	61.6	two sample t test. p =0.625
% of peds crossing none of the crosswalk during WALK	48.7	38.4	two sample t test p = 0.1106
% of cycles with conflicts	0.94	0.25	test P = 0.456
% of cycles where a pedestrian is trapped	17	8	two sample t test p = .0453
Latency between button press and WALK	not collected	not collected	not collected

These findings are not significant because of the small sample size

4.1.4 Leading Pedestrian Phase

Motorists often fail to yield to pedestrians crossing in marked crosswalks at controlled locations. Several studies, have documented the benefits of providing a short exclusive pedestrian phase at the start of the "WALK" at four-legged intersections. The purpose of this study was to examine the effect of a leading pedestrian signal phase (otherwise known as a lead pedestrian interval) at one four-legged intersection and one three-legged intersection in Miami Beach. The introduction of a brief leading pedestrian phase increased the percentage of drivers of left turning vehicles when a pedestrian was present yielding to the pedestrian starting to cross within four seconds of the start of the "WALK" which replicated previous work; however the study did not detect a change in the percentage drivers turning right yielding when a pedestrian was present. One reason for the absence of an effect for right turning vehicles was the high frequency of motorists making free flow right turns on red in Miami-Dade County. Data also showed that button presses increased following the introduction of the Leading Pedestrian Interval (LPI) condition. It is possible that the increase in button pressing was related to the improvement in the percentage of left turning drivers yielding to pedestrians crossing within four seconds of the start of the "WALK" signal. The results of the Leading Pedestrian Phase Intervention are presented in Table 4.4.

Table 4.4 Results of Leading Pedestrian Phase Intervention

Alton and Lincoln Rd.	Baseline	Treatment	Z score	p-value
Number of left turning vehicles	46	194		
Number of right turning vehicles	15	45		
% of left turning drivers yielding during WALK	40	58	3.933	0.01
% of right turning drivers yielding during WALK	15	15	NA	NA
Number of cycles ped present who could have pressed button	169	431		
% of cycles someone pushed call button	69	76	1.91	0.05
% cycles ped vehicle conflicts	Very rare event			
Total number of pedestrians that crossed	858	1121		
% of pedestrians crossing during first 4 s of WALK	45.3	76.5	14.72	0.01
% of pedestrians in crosswalk at end of all red	2.1	2.4	0.45	>0.05
Collins & 16th St.	**Baseline**	**Treatment**	**Z score**	**p-value**
Number of left turning vehicles	59	18		
Number of right turning vehicles				
% of left turning drivers yielding during WALK	22	31	1.952	0.05
Number of cycles ped present who could have pressed button	781	185		
% of cycles someone pushed call button	36	51	2.866	0.01
% cycles ped vehicle conflicts	Very rare event			
Total number of pedestrians that crossed	300	109		
% of pedestrians crossing during first 4 s of WALK	38	59	3.916	0.01

4.1.5 "TURNING VEHICLE YIELD TO PEDESTRIANS" Symbol Sign

Motorists often fail to yield to pedestrians in marked crosswalks at controlled locations. Several studies have documented the benefits of text signs instructing drivers of turning vehicles to yield right-of-way to pedestrians. The purpose of the present study was to compare a symbol sign with the standard text sign currently in the Manual of Uniform Traffic Control Devices (MUTCD. After collecting baseline data on the percentage of drivers yielding right-of-way to pedestrians crossing legally in the crosswalk at two sites with the text sign present, the symbol sign was installed and additional data were collected. In order to control for possible confounding variables the signs were changed at a different point in time at each site. Data revealed a general decreasing trend in the percentage of drivers yielding to pedestrians over the course of the study. The introduction of the symbol sign produced an increase in the percentage of drivers turning right and left that yielded to pedestrians at the second site but did not alter the downward trend in the data. At the first site changing the sign at two of the four legs of the intersection produced no level change and the downward trend continued. One reason why the sign may have been less effective at the first site may be related to the fact that the sign only changed to the symbol sign on two rather than all four legs. These results, presented in Table 4.5, show the importance of monitoring data collection over time and using a staggered introduction of the treatment in order to control for possible confounding variables when studies only compare treatments at a small number of sites.

Table 4.5 Results of "TURNING VEHICLE YIELD TO PEDESTRIANS" Intervention

Collins Ave & 17th St.	Baseline	Treatment	Z score	p-value
Number of crossing with turning veh present	330	570		
Number of Left Turning Vehicles	188	370		
% left turning vehicles yielding	59	51	neg 5.503	NS
Number of Right Turning Vehicles	217	432		
% right turning vehicles yielding	71	50	neg 6.573	NS
% crossings with ped vehicle conflicts	3	2	0.409	NS
% crossings with pedestrians trapped	2	3	0.979	NS

Collins Ave & 21st St.	Baseline	Treatment	Z score	p-value
Number of crossing with turning veh present	690	330		
Number of Left Turning Vehicles	487	207		
% left turning vehicles yielding	50	77	9.018	0.01
Number of Right Turning Vehicles	371	132		
% right turning vehicles yielding	63	79	5.451	0.01
% crossings with ped vehicle conflicts	No conflicts recorded			
% crossings with pedestrians trapped	1	2	1.567	NS

4.1.6 Electronic "NO TURN ON RED" Sign

Many drivers make right turns on red without stopping and some do so without even slowing more than they would if facing a green signal indication. This study compared the efficacy of a conditional "No Turn on Red When Pedestrians in Crosswalk" sign, the standard metal sign "No Turn on Red" (NTOR) sign and an electronic NTOR that is illuminated when a right turn on red is prohibited. The results of the experiment indicated 34 percent of drivers violated the NTOR prohibition with the conditional sign, and 41 percent violated it with the standard sign. The electronic sign reduced violations to 32 percent and they recovered to previous levels during a short return to the standard sign. Data also indicated that the percentage of violators making a full stop before violating NTOR increased from 29 percent and 31 percent for the conditional and standard NTOR sign during the baseline condition, to 78 percent with the electronic sign and to 65 percent during the short return to the standard NTOR sign condition. The results for violators making rolling stops or no stop at all show that the improvement in compliance was the result of equivalent large reductions in both types of violations. Data also indicated that the standard NTOR sign was associated with a decline in the percentage of violations when pedestrians were in the crosswalk, and that the electronic sign produced further declines in violations of pedestrian right-of-way. The results further documented a reduction of motor vehicle-pedestrian conflicts with the electronic sign but not with the standard NTOR sign. Increasing compliance with the NTOR prohibition associated with the electronic NTOR sign was also associated with an increase in the percentage of drivers blocking the crosswalk and a smaller increase in the percentage of pedestrians that needed to walk around vehicles when the crosswalk was blocked. The results of the Electronic No Right Turn on Red Sign intervention are presented in Table 4.6.

Table 4.6 Results of Electronic "NO TURN ON RED" Sign Intervention

MOEs	Baseline (conditional static)	Measure 1 (Static NRTOR)	Measure 2 (Active NRTOR)	Measure 3 (Static NRTOR)	Statistic
% Violation of NRTOR	34	41	32	48	ANOVA p=0.0008
% violations when ped present in the crosswalk	34	11	6	8	ANOVA p=0.0001
% violations when ped present at curb	90	94	25	92	ANOVA p=0.0001
% driver violators who made full stop	29	31	78	65	ANOVA p=0.0001
% driver violators who made rolling stops	30	29	9	20	ANOVA p=0.0001
% driver violators who did not stop	41	40	13	15	ANOVA p=0.0001
% Conflicts	1	2	0.1	0	ANOVA p=0.0001
% drivers who blocked crosswalk	20.2	21.1	No data collected	No data collected	No data collected
% pedestrians that walked veh blocking Xwalk	6.73	4.44	No data collected	No data collected	No data collected

There is no push button on this leg (this is also the leg with the serious right turn on red crashes.

4.1.7 Countdown Pedestrian Signals

This study examined whether the installation of pedestrian countdown signals could increase the percentage of pedestrians pressing the pedestrian call button. At one site there was a long delay after the baseline data were collected and before the countdown signals were installed. At the other site push buttons that provided feedback when the button was pressed were installed following the baseline study and then a countdown signal was installed. The installation of the countdown signal was associated with an increase in the percentage of pedestrians that pressed the call button at both sites. The results of the Countdown Pedestrian Signal Study are presented in Table 4.7.

Table 4.7 Results of Countdown Pedestrian Signals Study

	Alton and Lincoln			Alton and 16th			
MOEs	Baseline	Countdown	Statistic	Baseline	Button	After	Statistic
Number of crossings	450	450		600	810	300	
% Cycles the call button was pressed	35	95	31.13 (p=0.01)	40.3	62.7	79.7	19.5, p=0.01)
% peds in crosswalk at end of Flashing DON'T WALK	28	9	9.21 (p=0.01)	46.7	55	20.33	6.32 (p=0.01)
% Pedestrian violations	47.62	5.77	21.94 (p=0.01)	53.93	38.1	29.38	7.38 (p=0.01)
% conflicts	0.37	0.33	0.1	0.33	0	0.2	8.47 (p=0.01)

4.1.8 In-Street Pedestrian Sign

Motorists often fail to yield to pedestrians in marked crosswalks at uncontrolled locations. Several studies, including a recent NCHRP/TCRP study have demonstrated that the use of in-roadway signs can significantly increase the percentage of motorists yielding to pedestrians at uncontrolled marked crosswalks. The 2003 Edition of the MUTCD includes two in-street pedestrian signs that may be installed at uncontrolled locations but does not give precise directions as to where to place the sign in relation to the crosswalk. The purpose of the present FHWA study was to compare the effect of placing these signs at the crosswalk, 20 feet in advance of the crosswalk, 40 feet in advance of the crosswalk, and placing a sign at all three locations on driver yielding behavior. A counterbalanced multi element design was employed in this experiment. This design involves installing the sign at several different locations in advance of the crosswalk to determine if there is an optimum location to place the sign. After collecting baseline data at all three crosswalks on Collins Avenue in Miami Beach, Florida, the research team placed the sign at each of the three distances in advance of the crosswalk at each crosswalk location as well as at all three locations together in randomized blocks of trials to control for order effects. The data showed that the sign produced a marked increase in yielding behavior at all three crosswalks and that installing the signs at the crosswalk line was as effective as or more effective than installing it 20 or 40 feet in advance of the crosswalk. Data also indicated that placing the sign at all three locations at once was no more effective than placing the sign at the crosswalk line. These data suggest that the in-roadway sign are likely effective because the in-roadway placement is particularly salient to drivers. Because vehicles frequently struck the signs on Collins Avenue it is recommended that these signs be placed on median islands wherever possible to extend their useful life. The results of the In-Roadway Yield to Pedestrians Signs are presented in Table 4.8. This study was published in Transportation Research Record No. 2002 (Ellis, Van Houten and Kim, 2007).

Table 4.8 Results of In-Street Pedestrian Sign Study

Collins & 6th						
Number of peds	400	440	240	240	240	
% Yielding	32	78	75	70	79	Significant increase; 0 and 3 signs higher than 40
Z score		12.93	10.18	8.65	11.52	
P value		0.01	0.01	0.01	,01	
Collins & 9th						
Number of peds	400	240	240	240	240	
% Yielding	21	65	63	54	56	Significant increase
Z score		10.39	9.93	7.87	8.23	
P value		0.01	0.01	0.01	0.01	
Collins & 13th						
Number of peds	1300	200	400	400	160	
% Yielding	34	69	43	43	52	Significant increase; 0 and 3 signs higher than 20 & 40
Z score		11.2	6.26	6.26	6.03	
P value		0.01	0.01	0.01	0.01	

Driver Pedestrian Conflicts						
Collins & 16th	Rare at all three locations and only occurred during baseline conditions					
Collins & 9th						
Collins & 13th						
% Pedestrians trapped in roadway						
Collins & 6th	0.05	0	0	0	0	
Collins & 9th	0	0	0	0.006	0	
Collins & 13th	0.0059	0	0.01	0.003	0	these numbers are too low to test.

4.1.9 Pedestrian Zone Signs

Many urban areas associated with nighttime entertainment have a high proportion of pedestrian crashes. In these areas drivers may not attend to pedestrians using crosswalks. One way to address this problem is to erect a W 11-2 sign in conjunction with a supplemental "Next 2 Miles" plaque. This study evaluated the effect of this sign and plaque combination on motorist speed and braking for pedestrians in a high pedestrian area of Collins Avenue in Miami Beach. Vehicle speeds were measured using microwave radar and observers recorded driver braking for pedestrians in the roadway. Speed data showed that drivers slowed to 12 mph when pedestrians were present, before and after the signs were installed. Braking data showed similar results. These data were recorded during daytime hours and it is possible that better results would be obtained at night or if speeds were higher. The results of the Pedestrian Zone Signs are presented in Table 4.9.

Table 4.9 Results of Pedestrian Zone Signs Study

MOEs	Before	After	Statistic
Number of pedestrians	240	270	
Vehicle speed (kph)	19.5	19.7	p=1.79
% Driver braking	57	63	p=1.36
% Conflicts	0	0	N/A
% Pedestrians trapped	0.0042	0.0111	Z = 0.912 (P > 0.05)

4.1.10 Speed Trailers

Speed trailers have been documented to be effective at decreasing speeds in work zones by as much as 10 mph (Fontaine, Carlson and Hawkins, 2000) and by four to five mph in a second study (McCoy, Bonneson and Kollbaum, 1995). Studies have also documented that speed trailers are effective in reducing speeds on low-speed urban roadways (Perillo, 1997), but the effects do not persist after the trailer is removed (Perillo, 1997) if there is no enforcement, but may persist if the trailer is associated with speed enforcement (Bloch, 1998). The purpose of this study was to examine whether speed trailers reduced speeds and increased braking when pedestrians were present. Participants were motorists driving on or pedestrians crossing Collins Avenue between 38th and 39th Streets. Although the speed trailer increased braking it failed to reduce speed. Because mean speed was 25 mph, which is below the posted limit, motorists may not have perceived a need to reduce their speed further. These data were recorded during daytime hours because at this time the number of pedestrians was highest although it is possible that better results would be obtained at night or at sites where speeds are higher. The results of the Speed Trailer study are presented in Table 4.10.

Table 4.10 Results of Speed Trailers Study

MOEs	Before	After	Statistic
Number of Peds	344	300	
Number of Vehicles	644	549	
Vehicle speed (mph)	26	26	Z=1.43
% Driver braking	44	53	Z=2.288 (p=0.05)
% Conflicts	0	0	N/A
% Pedestrians trapped	0	0	N/A

4.1.11 Rectangular LED Stutter Flash

Motorists often fail to yield to pedestrians in marked multilane crosswalks at uncontrolled locations. Several studies have demonstrated that the use of advance yield markings along with a yield here to pedestrian sign can reduce the threat of multiple threat crashes but only have a small effect on overall driver yielding behavior. Several studies, including a recent NCHRP/TCRP study have demonstrated that the use of the HAWK signal can significantly increase the percentage of motorists yielding to pedestrians at uncontrolled marked crosswalks. This device has high compliance because it includes a red phase and a flashing red phase similar to the signals used at fire stations. Although this signal is highly effective its high cost limits its use to particularly risky crosswalks. A lower cost alternative to the HAWK signal is the use of rectangular LED rapid flash amber beacons with an irregular wig wag flash pattern installed on the pedestrian warning sign. We evaluated the rectangular LED rapid flash beacon at two multilane crosswalks in Miami Beach, Florida under FHWA permission to experiment as part of an FHWA Cooperative Agreement to evaluate ITS treatments to increase yielding behavior. A reversal design was employed in this experiment to demonstrate experimental control at each site. This design involves alternating sessions when the signals were activated with sessions when the device was not activated. The results showed that the rectangular LED rapid flash beacons produced a marked increase in yielding behavior at both crosswalks and that similar data were collected from staged pedestrians and local residents using the crosswalks. Data also indicated that the use of the device produced a reduction in evasive conflicts between drivers and pedestrians at both sites and a reduction in the percentage of pedestrians trapped in the center of the road at the crosswalk without a median island. This paper will appear in a future Transportation Research Record. [1]

[1] *Shurbutt, J., Van Houten, R. & Turner, S. (in press). An Analysis of the Effects of Stutter Flash LED Beacons to Increase Yielding to Pedestrians Using Multilane Crosswalks. Transportation Research Record.*

Table 4.11 Results of Rectangular LED Stutter Flash Study

Analysis of Variance comparing flasher and no flasher conditions on vehicle yielding to staged crossings at N.W. 67th & Main St.

Source	*SS*	*df*	F	*p*
Between Groups	30047.58	1	256.12	3.4057E-20*
Within Groups	5279.39	45		
Total	35326.97	46		

Analysis of Variance comparing flasher and no flasher on vehicle yielding to local resident crossings at N.W. 67th & Main St.

Source	*SS*	*df*	F	*p*
Between Groups	29666.11	1	53.18	2.7388E-08*
Within Groups	17849.71	32		
Total	47515.82	33		

Analysis of Variance comparing flasher and no flasher conditions on vehicles yielding to staged crossings at S. Bayshore Dr. & Darwin.

Source	*SS*	*df*	F	*p*
Between Groups	31518.61	1	467.9	2.51E-23*
Within Groups	2627.11	39		
Total	34145.72	40		

Analysis of Variance comparing flasher and no flasher conditions on vehicle yielding to local residents on S. Bayshore Dr. & Darwin.

Source	*SS*	*df*	F	*p*
Between Groups	46885.34	1	148.85	3.6849E-13
Within Groups	9449.52	30		
Total	56334.87	31		

Analysis of Variance comparing flasher and no flasher conditions on the percent of evasive conflicts at N.W. 67th & Main St.

Source	*SS*	*df*	F	*p*
Between Groups	159.02	1	6.63	0.01329
Within Groups	1102.96	46		
Total	1261.98	47		

Analysis of Variance comparing flasher and no flasher conditions on the percent of evasive conflicts at S. Bayshore Dr. & Darwin.

Source	*SS*	*df*	F	*p*
Between Groups	105.14	1	13.85	0.0006
Within Groups	280.75	37		
Total	385.89	38		

Analysis of Variance comparing flasher and no flasher conditions on pedestrians trapped between in the center of the road.

Source	*SS*	*df*	F	*p*
Between Groups	13222.24	1	82.47	1.8382E-11
Within Groups	6734.10	42		
Total	19956.34	43		

4.1.12 Dynamic Lighting

A second experiment evaluated the effects of illuminating the departure area with LED lighting when the rectangular LED rapid flasher beacon was activated at night. This treatment did not produce a further increase in yielding. It is likely that the salience of the LED stutter flash beacons overshadowed the effect of departure pad lighting. The results of the Dynamic Lighting study are presented in Table 4.12.

Table 4.12 Results of Dynamic Lighting Study

Analysis of Variance compariing total vehicle yielding and non-yielding during auxiliary pedestrian light on and off conditions at S. Bayshore Dr. at Darwin				
Source	SS	df	F	p
Between Groups	113.79	3	0.43	0.7335
Within Groups	1762.83	20		
Total	1876.62	23		

4.1.13 Remove Permissive Left Turn Phase

Studies have consistently found higher crash rates for left turning movements at intersections over right turning movements. The use of a leading protected left turn phase reduces driver workload by eliminating the need to search for a gap in opposing traffic. Pedestrians are held during this condition to further improve safety. However, many pedestrians violate the pedestrian signal crossing during the protected left turn phase and drivers may not search for pedestrians assuming none will be crossing. If a permissive left turn phase follows the protected left turn phase pedestrians may fail to benefit from the introduction of a leading protected left turn phase. However, if permissive left turns are not permitted pedestrians should not encounter conflicts with turning vehicles unless drivers violate the signal. The purpose of this study is to compare pedestrian and vehicle violations and motor-vehicle/pedestrian conflicts during a leading protected/permissive left turn condition vs. a leading protected without permissive left turn condition. Participants were pedestrians crossing the South leg of Pine Tree Drive at the intersection of 41st Street and West bound drivers on 41st. Street turning left onto Pine Tree Drive. Data were collected during daylight hours Monday through Saturday. The results of this study indicated changing from leading protected/permissive left turn phasing; to a leading protective/prohibited left turn phasing decreased motor vehicle/pedestrian conflicts. However, many pedestrians continued to cross when the cross traffic stopped at the start of the protected left turn phase in violation of the DON'T WALK signal even though there was a slight improvement in compliance. The improvement in compliance by pedestrians was more than offset by the high violation rate of drivers early during the prohibited left turn phase. These drivers were waiting in queue and attempted to squeeze through the beginning of the prohibited turn phase. A better way to increase the safety of pedestrians at busy intersections may be to use a lagging protected left turn phase rather than a leading protected phase. A lagging protected left turn phase would give pedestrians priority increasing pedestrian compliance. Furthermore, most pedestrians would clear the intersection before left turning vehicles are released. The results of the Remove Permissive Left Turn Phase study are presented in Table 4.13.

Table 4.13 Results of Remove Permissive Left Turn Phase Study

MOEs	Protected Permitted		Protected Prohibited		Statistic
	Veh Protect	Veh Perm	Veh Protect	Veh Proh	
Number of Left Turning Vehicles	3084	1560	1373	252	
Number of Pedestrians Crossing	359	1807	105	684	
Number of Conflicts	32	22	12	4	
% of Conflicts	7.219		2		t=2.50 p=0.014
% pedestrians crossing during WALK	84		86.69		t=-6.31 p=0.00
% Pedestrians crossing during the protected LT phase	16		13.3		
% vehicles turning left during permissive LT phase	34				NA
% vehicles turning during protected LT phase	66		85		t=-20.22 p=0.00
% turning during prohibited LT phase			15		NA

4.1.14 ADVANCE YIELD MARKINGS

This countermeasure was not evaluated.

4.1.15 OFFSET STOP LINES

This countermeasure was not evaluated.

4.2 CRASH ANALYSIS All TREATED CORRIDORS

Data were collected for each corridor for 6 years prior to the introduction of the NHTSA project, for the 3 years that the NHTSA project was implemented, and for an additional 2 years that the FHWA project was implemented. This provides a total of 11 years of crash data along these high crash corridors. Figure 4.2.1 shows the crash rate for all eight treated corridors remained reasonably stable with a slight downward trend during the 6 years prior to the introduction of the NHTSA project. The introduction of the NHTSA project appeared to lead to a small decrease in pedestrian crashes form a mean of 101 during the baseline period to a mean of 87 (a decrease of 11.5%) during the three years that the NHTSA project was in effect. The installation of the engineering countermeasures on top of the NHTSA education and enforcement efforts lead to a further reduction to an average of 51 crashes per year. This represents a 50% reduction over the baseline level and a 41% reduction from the NHTSA project levels. It is interesting to note that during the 9 years prior to the FHWA project there were 15,472 pedestrian crashes in Miami-Dade County. Of these 46% occurred on State and County Roads for a total of 7,117 crashes or 791 crashes per year. Around 100 per year or nearly 13% of these crashes occurred along the treated corridors.

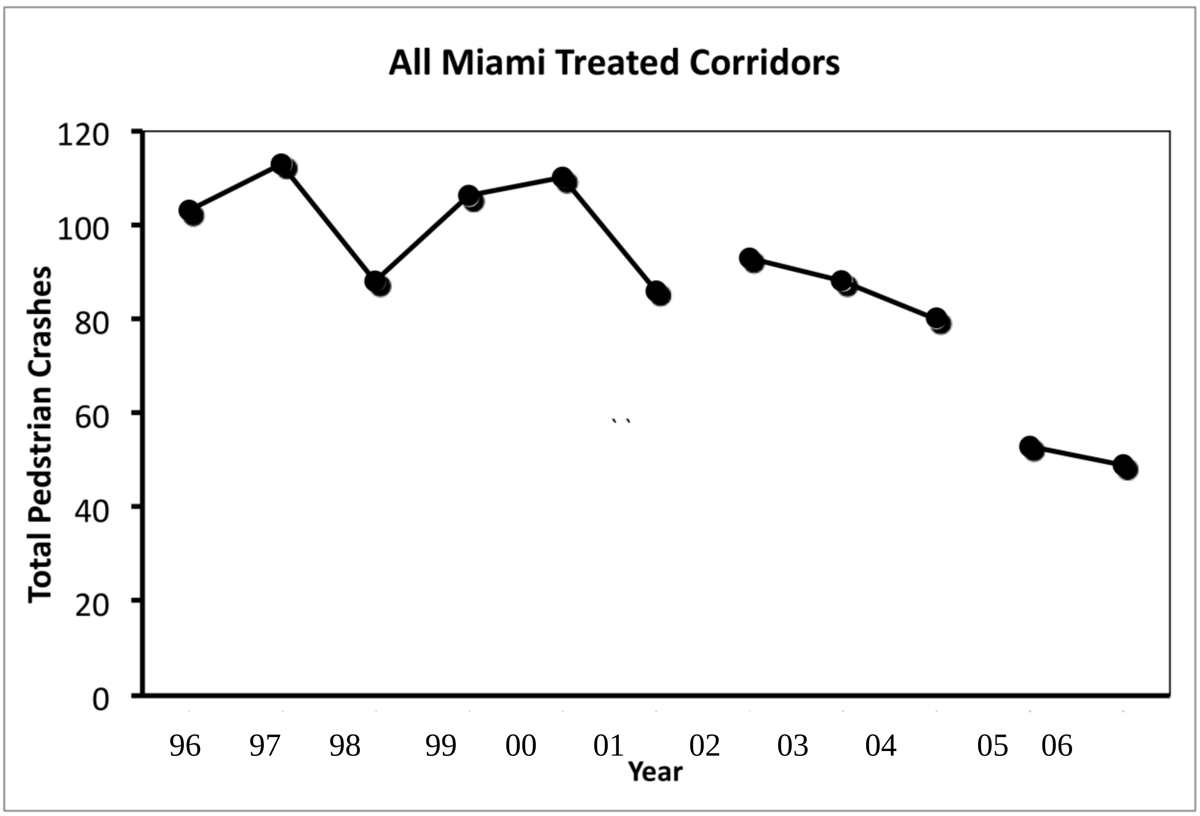

Figure 4.2 Crashes per Year for All Eight Crash Corridors from 1996-2006

4.3 INDIVDUAL CORRIDOR CRASH DATA

4.3.1 41ST Street (Alton Rd. to Pine Tree Dr.)

It is interesting to note that crashes declined in each of the eight crash corridors. Data from each corridor is presented below. One corridor that was not particularly responsive to the NHTSA treatment but very responsive to the FHWA engineering treatments was 41st Street; Alton Road to Pine Tree Drive. This corridor had the highest percentage of daytime pedestrian crashes of all eight corridors (81%). The results for this location are presented in Figure 4.2.2. Crashes averaged 7 per year during baseline, 5.3 per year during the NHTSA program, and 2 per year during the FHWA program. This corridor received a large number of countdown timers, push buttons that confirmed the press, the no right turn on red electronic sign, and the prohibited permissive left turn treatment. Data for this corridor are presented in Figure 4.3.

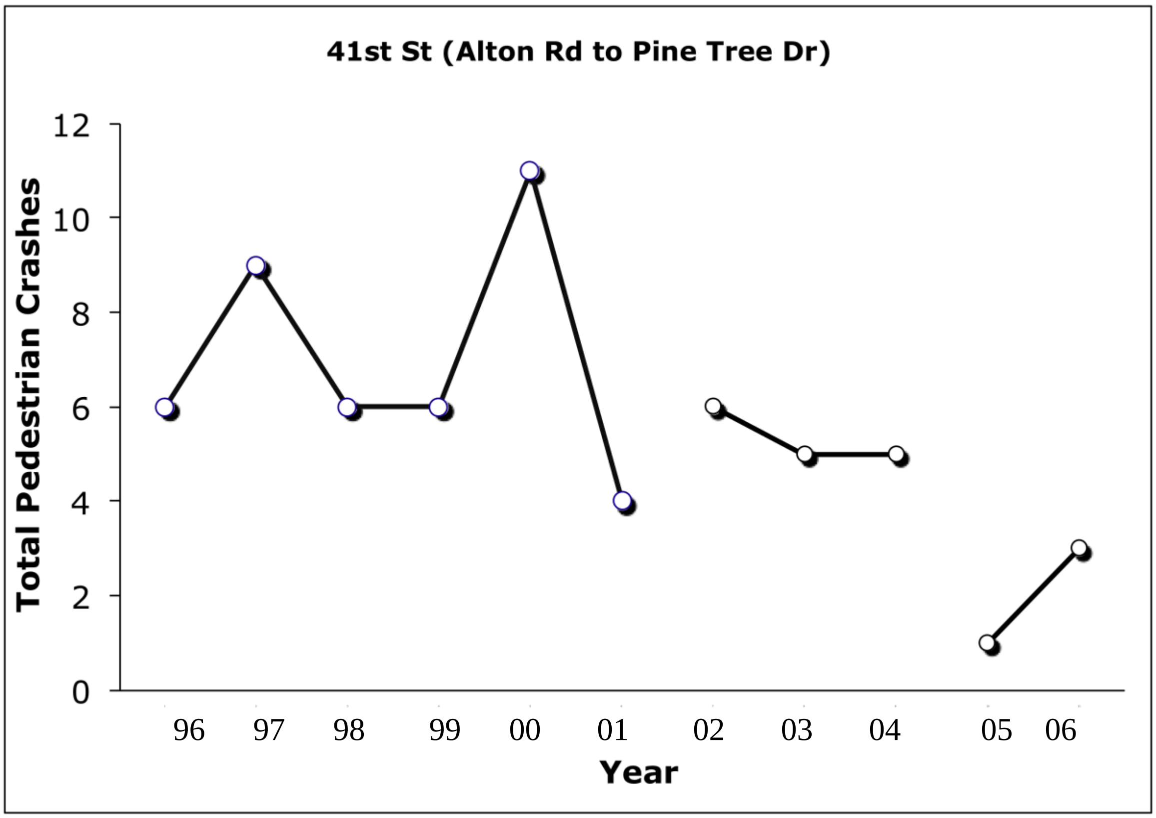

Figure 4.3 Crashes per Year for 41st St.; Alton Rd. to Pine Tree Dr. 1996-2006

4.3.2 NE6TH St. (NE 141ST St. to NE 151ST St.)

Another corridor that responded well to the engineering treatments was NE 6th St. (NE 141st St. to NE 151st St.). Many of the pedestrians struck in this corridor were children who were hit in crosswalks near the school. This corridor had the highest percentage of crashes involving children and youth (34%) and the highest percentage of crashes involving African American pedestrians (73%). During baseline crashes averaged 7.7 per year at this site and maintained at 8.0 during the three years of the NHTSA project. The FHWA project was associated with at reduction in crashes to 3 per year. This site also received countdown timers and push buttons that confirmed the press at high crash intersections and a large number of pedestrian zone signs. Data from this site are presented in Figure 4.4.

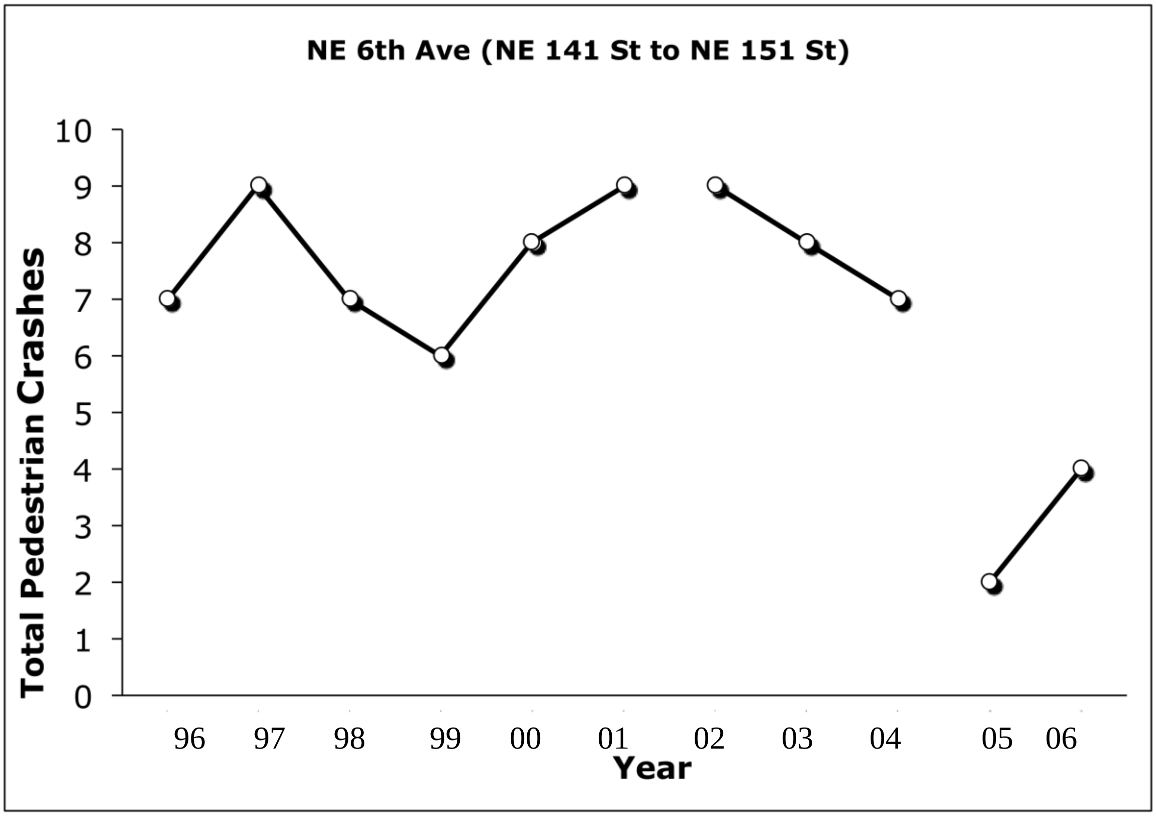

Figure 4.4 Crashes per Year Along NE 6th St. (NE 141st St. to NE 151st St.) from 1996 to 2006

4.3.3 NE 163RD St. (NW 2ND Ave. to Biscayne Blvd)

The corridor that showed the largest improvement also had the highest number of crashes per year during baseline, the second highest percentage of African American pedestrians struck during baseline (41%), and the second highest percentage of senior pedestrians struck during baseline (28%). Baseline data show a downward trend during the baseline period. This corridor had the second highest percentage of pedestrian crashes involving turning vehicles (60%). This large corridor along NE 163rd St. had 25.8 crashes per year during baseline, crashes declined to 20.7 crashes per year during the NHTSA project and declined further to 8 per year during the FHWA project. This corridor also received the largest number of countermeasures. This corridor had a large number of countdown pedestrian signals and push buttons that confirmed the press installed. This site also received 'Turning Vehicles Yield To

Pedestrians" symbol signs, and a large number of offset stop lines. Data for this corridor are presented in Figure 4.5.

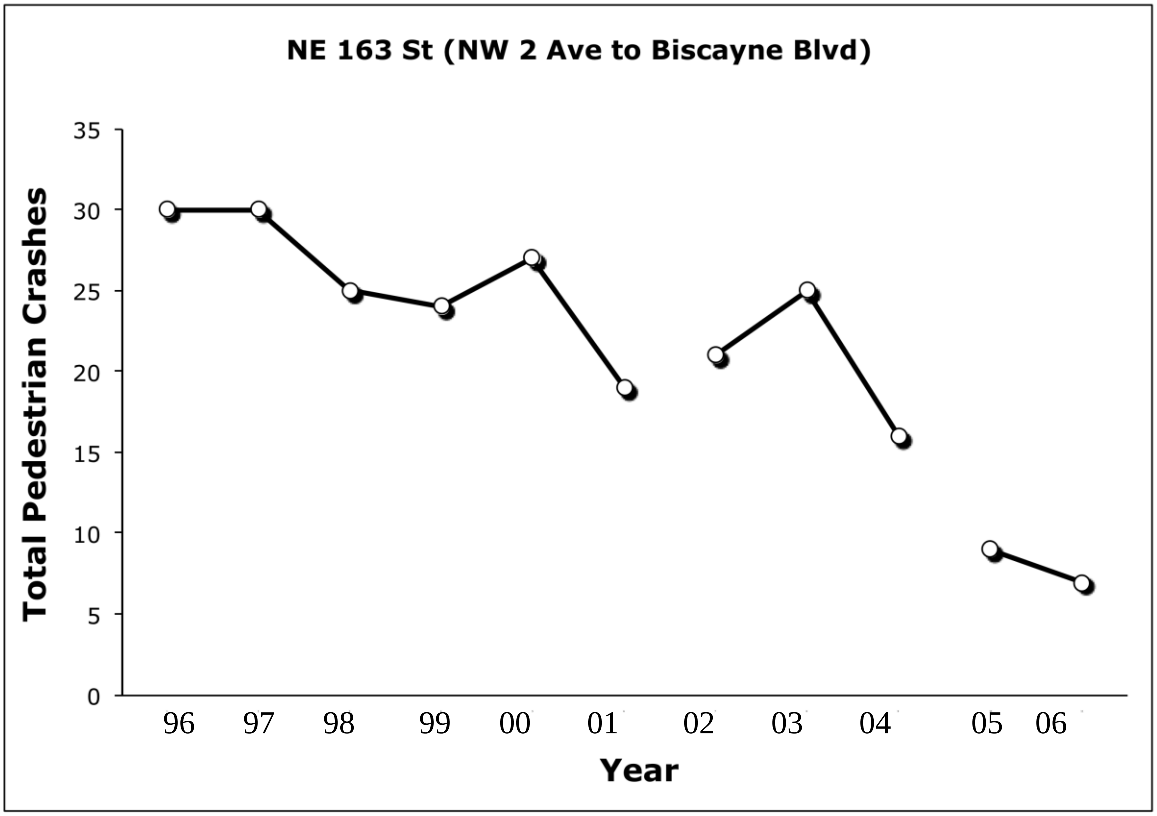

Figure 4.5 Crashes per Year NE 163rd St. (NE 2nd Ave to Biscayne Blvd.) from 1996 to 2006

4.3.4 Collins Ave (5TH St. to 24TH St.)

This corridor on Collins Ave. between 5th St. and 24th St. was in the middle of the South Beach recreational area. Therefore it is not surprising that this corridor had the highest percentage of nighttime crashes of all eight corridors (55%). During baseline there were 18.8 pedestrian crashes per year along this corridor. During the NHTSA project there were 20 crashes per year. The introduction of the FHWA project was associated with a decline in crashes to 13 per year. One of the treatments that was effective along this corridor was the in street pedestrian signs. Unfortunately these signs did not stand the test of time and were only in effect for a relatively short period of time. This corridor also received a couple of lead pedestrian intervals, a large number of "Turning vehicles yield to pedestrians" symbol signs, some pedestrian zone signs, and one advance yield marking. Crash data are presented in Figure 4.6.

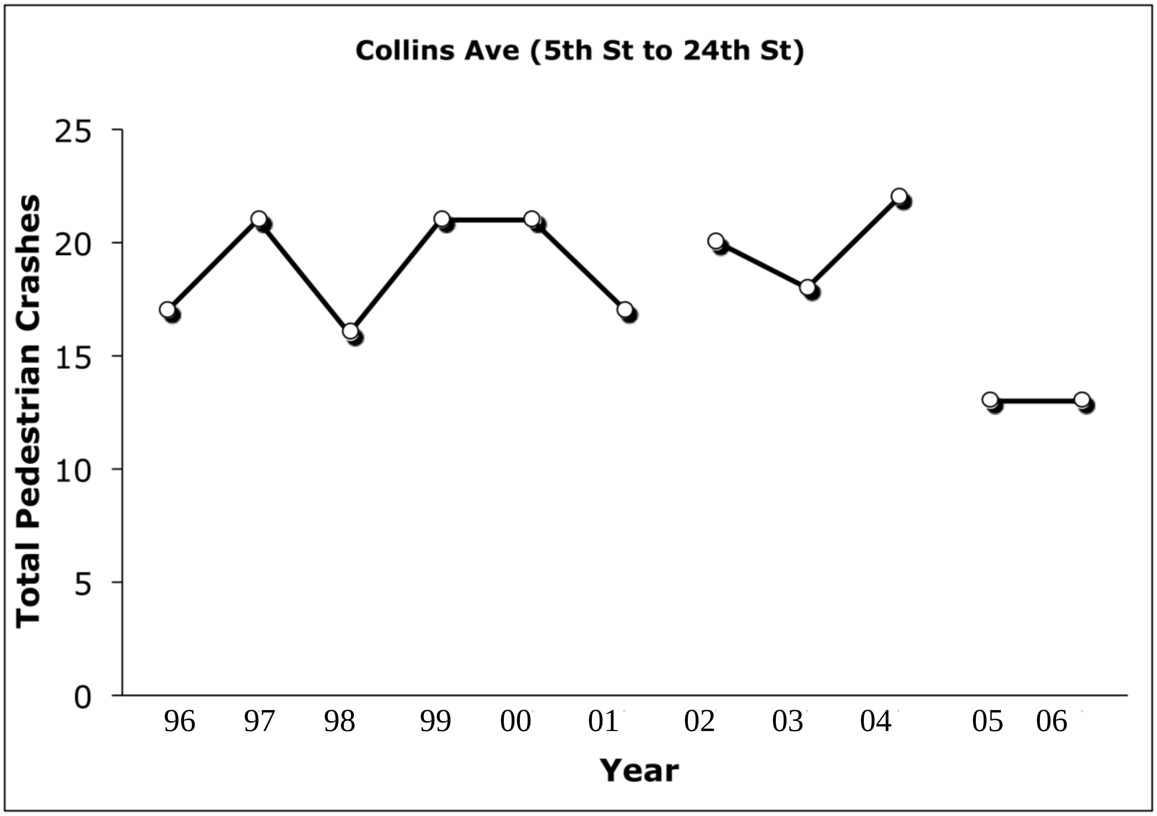

Figure 4.6 Crashes per Year Collins Ave. (5th Street to 24th St.) from 1996 to 2006

4.3.5 Collins Ave-Indian Creek (28TH St. to 43RD St.)

This corridor is immediately adjacent to the Collins Ave (5th to 24th St.) corridor. Treatments installed along this corridor included "TURNING VEHICLES YIELD TO PEDESTRIANS" symbol signs, and the use of the speed trailer, Crashes averaged 7 per year during the baseline period along this corridor, 5.3 per year during the NHTSA project and 3 per year during the FHWA project. The graph of the yearly crash data is shown in Figure 4.6. Although the average number of crashes is lower during the FHWA study there are too few crashes and too much overlap to conclude much about the efficacy of the treatment at this location.

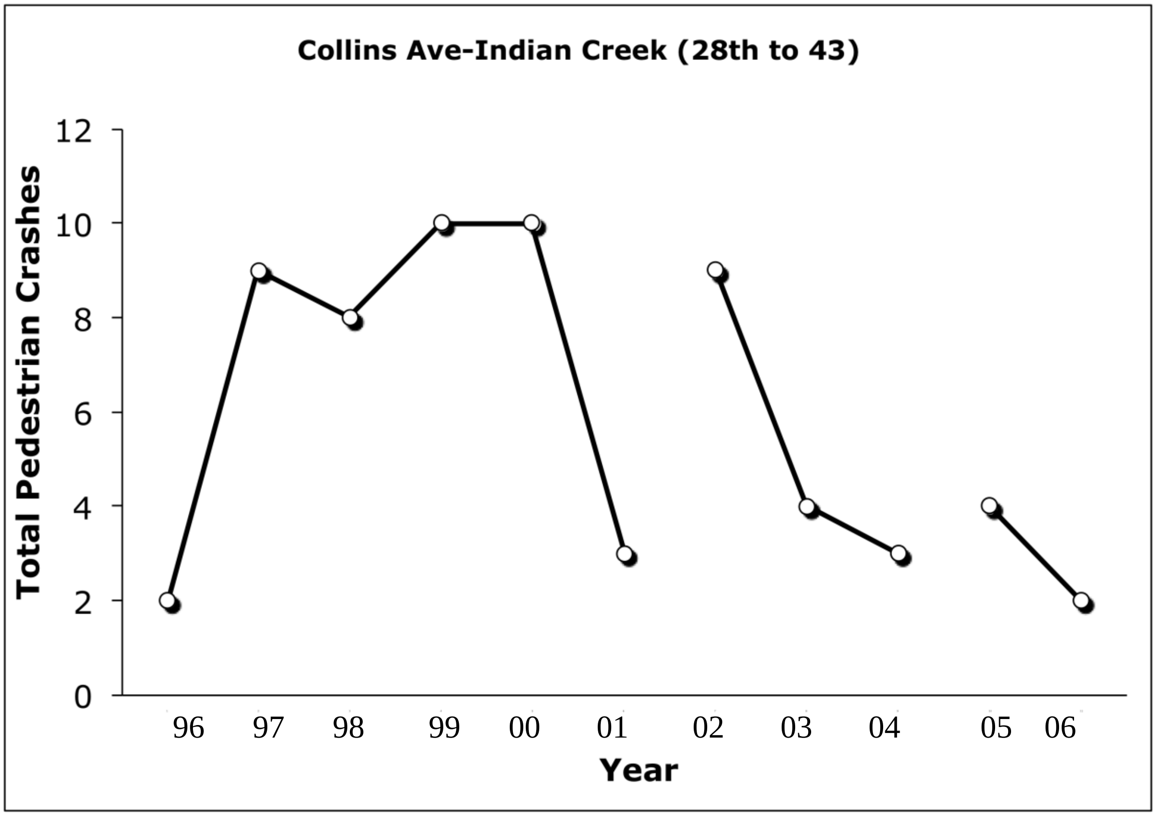

Figure 4.7 Crashes per Year Collins Ave. (Indian Creek 28th St. to 43rd St.) from 1996 to 2006

4.3.6 Collins Ave & Harding Ave. (65TH St. to 75TH St.)

This crash corridor had the highest percentage of crashes involving turning vehicles during baseline of all of the selected corridors averaging 80% and the highest percentage of pedestrians struck over the age of 65 years (49%). Treatments installed along this corridor included "Turning vehicles yield to pedestrians" symbol signs, pedestrian zone signs, and the speed trailer. During the baseline condition the number of crashes per year averaged 14.3, during the NHTSA project crashes averaged 13 per year and during the FHWA project they averaged 9.5 per year. Overall it appeared the treatments were only moderately effective at this site. A graph of the yearly crash data is shown in Figure 4.8.

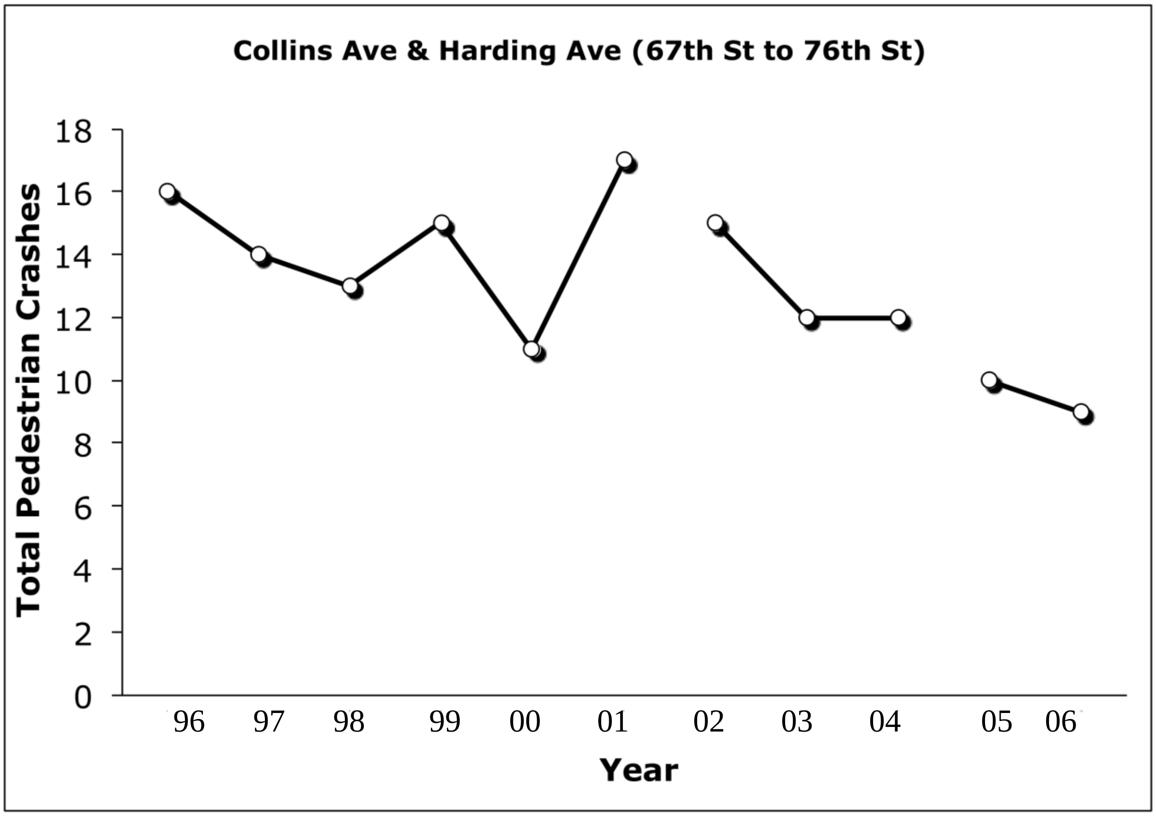

Figure 4.8 Crashes per Year Collins Ave. and Harding Ave. (67th St. to 76th St.) from 1996 to 2006

4.3.7 Alton Road (5TH St. to 17TH St.)

The corridor along Alton Road between 5th St. and 17th St. averaged 13.8 crashes per week during baseline. This corridor had the second highest percentage of daytime crashes (74%) and 42% of crashes occurred at intersections. Alton Rd. received a number of treatments. A large number of push buttons that confirmed the press and countdown pedestrian signals were installed along this corridor. The video detection system was installed at a midblock signalized crosswalk. Three intersections received a leading pedestrian interval, and one intersection received the “Turning vehicles yield to pedestrians” symbol sign treatment. The introduction of the NHTSA project was associated with a decline in crashes to 10 per year and the FHWA project was associated with a further small decline to 8.5% crashes per year. A graph of these data is shown in Figure 4.9.

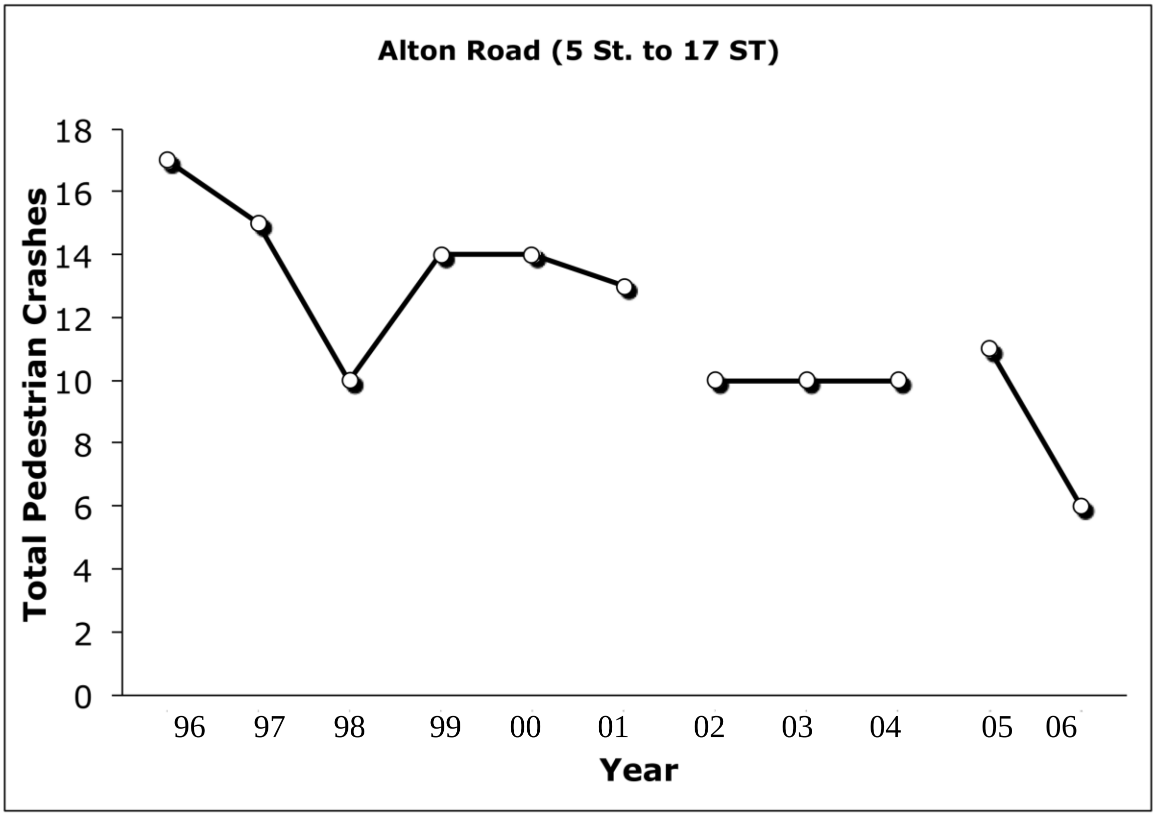

Figure 4.9 Crashes per Year on Alton Rd. 5th St. to 17th St.) from 1996 to 2006

4.3.8 5TH St. (Alton Rd. to Ocean Dr.)

The final graph shows the number of crashes occurring on 5th St. between Alton Rd. and Ocean Drive. More than half the crashes along this corridor occurred at night and only 23% involved turning vehicles. Treatments installed along this corridor included push buttons that confirmed the button press, and “Turning vehicles yield to pedestrians” symbol signs. During the baseline condition pedestrian crashes averaged 6.5 per year. After the NHTSA program was introduced these crashes declined to 4.7 per year and following the introduction of the FHWA project crashes declined to 4 per year. Figure 4.10 shows crashes at this site. Overall there were not a large number of crashes along this corridor and it is difficult to determine whether the treatments had an effect.

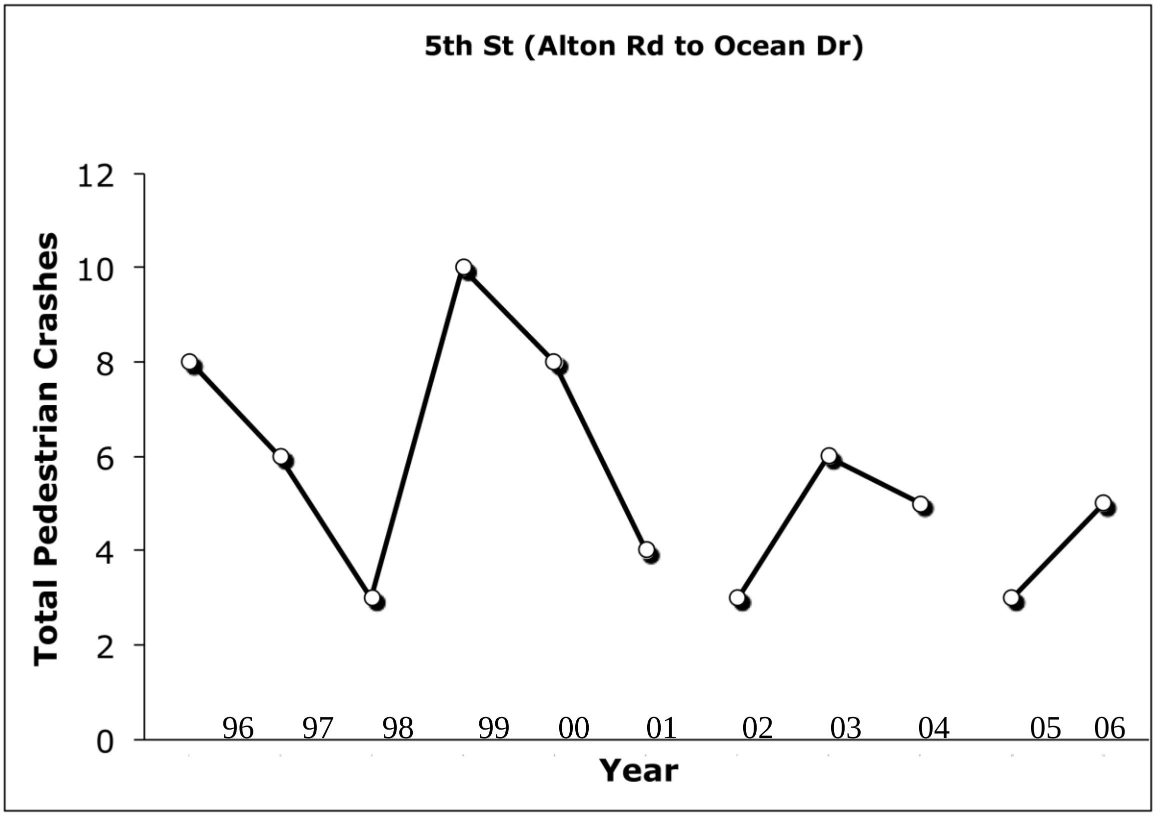

Figure 4.10 Crashes per Year on 5th St. Between Alton Rd. and Ocean Dr.) from 1996 to 2006

CHAPTER 5 OUTREACH AND EDUCATION

All of the traffic control devices deployed in this study were intuitive or passive in nature and therefore required little outreach and awareness training. Countdown pedestrian signals, offset stop lines, push buttons that confirm the button press, automatic pedestrian detectors (passive in nature), a leading pedestrian phase, "Turning vehicles yield to pedestrians" signs, in roadway signs, elimination of permissive left turns, dynamic NTOR signs, the rectangular LED stutter flash, dynamic lighting (passive in nature), pedestrian zone warning signs, shorter minimum green waiting times, and advance yield markings are familiar to motorists and pedestrians. Therefore outreach and awareness focused on continued enforcement along with a continuation of the general educational countermeasures deployed as part of the NHSTA Miami Dade Contract that begun prior to the FHWA Cooperative Agreement. On of the team members on the Cooperative Agreement (David Henderson of the Miami-Dade MPO) coordinated these efforts. These ongoing outreach and awareness measures are summarized below:

1. Pedestrian safety message posters mounted in bus and Metrorail trains. These included six different messages aimed at increasing pedestrian safety practices and were written in English, and Spanish.

2. WalkSafe Program and Ryder Trauma Center Classroom Education—program aimed at reducing the incidence of children struck by vehicles by educating elementary school-aged children, teachers, parents and their communities about traffic safety. The program used an educational training intervention, appropriate engineering countermeasures, and an enforcement component to help achieve its goal. An evaluation of the program can be found in Hotz and colleagues (2004).

3. Walk to School Day Sponsored by SAFE KIDS Walk This Way—Thousands of students from 8 schools participated in Walk to School Day. The National SAFE KIDS Campaign provided banners, signs, pedestrian safety pamphlets, and safe walking surveys.

4. Pedestrian Education by the Community Affairs Bureau of the Miami-Dade Police Department—The Pedestrian Safety Section of the Miami-Dade Police Department's Community Affairs Bureau made numerous traffic safety presentations in schools, distributed several safety booklets and materials, and helped establish the WalkSafe Miami program.

5. Haitian Creole Elementary School and Older Pedestrian Safety Education Programs—the elementary school program consisted of four 45-minute workshops conducted at three elementary schools, reaching 389 children. Both programs were supported by radio advertisements, Haitian web sites, a brochure in Haitian Creole, and Haitian Creole trading cards.

6. Brochure: Safety Tips for Pedestrians in Haitian Creole—pamphlet that provides pedestrian safety advice to adults.

7. Heroes of Haitian Independence Trading Cards—four cards that each depict a hero of Haitian independence on one side and provide pedestrian safety tips on the other.

8. Walk Safely Brochures in English and Spanish were delivered to the Miami-Dade school board, hospitals, public libraries, and police departments.

9. Workshops provided by the Miami-Dade MPO pedestrian-bicycle coordinator to older pedestrian groups on pedestrian safety.

10. More than 400 posters on nighttime conspicuity were delivered to organizations to display in public buildings.

11. Public Service Announcements (PSAs)—PSAs about pedestrian safety were distributed and broadcasted on city and county access channels in Spanish and English and on selected Spanish speaking radio stations.

12. Brochure: Pedestrian, Walk Safely—brochure providing families with the pedestrian safety advice in both English and Spanish. Brochures were delivered to organizations such as the Miami-Dade School Board, hospital, public library, police departments, and elected officials' offices.

13. Walking Through the Years: Pedestrian Safety for the Older Adult—booklet prepared for older (65+) adults and implementers of programs for older adults. Brochures were delivered to organizations such as the Miami-Dade School Board, hospital and medical departments, retirement homes, public library, police departments, elder affairs, and elected officials' offices.

14. Caminando a Traves de los Anos: Seguridad para Peatones de Tercera Edad (65+)—booklet in Spanish prepared for implementers of pedestrian programs for the older (65+) adult. Brochures were delivered to organizations such as the Miami-Dade School Board, police departments and elected officials' offices.

15. Enforcement of Driver Yielding Behavior Study, Two Police Pedestrian Safety Training Programs, and Enforcement—Van Houten and Malenfant (2003) conducted a study of driver yielding behavior at four crosswalks in each of two—an east and west—high crash corridors in the City of Miami Beach. In one year, police stopped 2,006 motorists for failing to yield to pedestrians, with 1,218 of these stopped during the first two weeks of the program. Three hundred thirty nine citations were issued, of which 188 were given during the first two weeks of the program. For enforcement results, review Van Houten and Malenfant (2003). Additionally, police officers in Miami Beach and Miami Springs received training on pedestrian safety and enforcement activities that have been used to address a variety of violations

and behaviors that often lead to collisions between pedestrians and motor vehicles.

16. Walking Through the Years: Pedestrian Safety for Your Child brochures (in English and Spanish) were distributed to the Miami-Dade School Board, hospital and medical departments, public libraries, and police departments. These brochures provided safety guidelines to parents and caregivers to help protect children from pedestrian crashes.

CHAPTER 6 PHASE II CONCLUSIONS

6.1 LESSONS LEARNED

6.1.1 Lessons Learned: Overall Project Success

The project was successful in demonstrating the ability of a local government/university team to develop a data based plan to improve pedestrian safety, focusing on higher-injury areas, and then to implement and evaluate this plan. The positive aspect of the program was the focus on low cost innovative engineering improvements to address pedestrian crashes in each corridor. It also provided an opportunity for the Miami-Dade team to take a cooperative approach with FHWA and the other two teams to identify best practices in pedestrian safety.

Because Miami-Dade had the previous experience with the NHTSA project that emphasized education and engineering countermeasures, the Miami-Dade team was well positioned to continue these extensive measures and to build on them to implement a complete multifaceted triple E program with heavy emphasis on Engineering, Education and Enforcement.

The focus on low cost engineering provides a model of what is possible in the absence of a large corridor wide engineering project. The Florida Department of Transportation often implements corridor wide safety projects that involve large scale improvements. These projects typically produce large benefits for all road users. In this project rather meager resources were utilized to produce large changes in 8 corridors that lead to significant crash reductions.

The federal funding was extremely helpful and appreciated as was the enhancements provided by FDOT and Miami-Dade County that assisted us in demonstrating the effectiveness of targeted low cost improvements.

6.1.2 Crash Reductions

The most important lesson learned was that inexpensive pedestrian safety engineering measures could produce a very significant reduction in crashes when introduced on top of an existing public education and enforcement program focusing on pedestrian safety. The installation of the engineering countermeasures on top of the NHTSA education and enforcement efforts lead to a reduction of 51 crashes per year for all sites. This represents a 50% reduction over the baseline condition and a 41% reduction from the NHTSA project levels. Because we selected high crash corridors and the crash reduction was so large, the overall reduction in our 8 corridors represented a 6.5% reduction in all crashes on State and County roads in Miami-Dade County.

6.1.3 Lessons Learned from Experimentation

A number of lessons were learned from the experimentation conducted as part of this study and the results have been published in four papers in *Transportation Research Record*. Additional papers will be submitted for publication this year.

Highlights of Research Results

- That the probability of a pedestrian violation at midblock signals is a joint function of perceived risk and wait time. Reducing wait time leads to very high levels of compliance.
- That the in street pedestrian sign is best placed close to the crosswalk, and that no advantage is gained by installing multiple signs.
- That pedestrian push buttons that confirm the press lead to more pedestrians pressing the button and more pedestrians that press the button waiting for the WALK indication.
- That the rectangular LED rapid flash beacon is associated with high levels of yielding on multilane high volume roads during the day and night.
- That the electronic NRTOR signs lead to fewer pedestrian conflicts with vehicles turning right-on-red and that more drivers who violated first came to a full stop, while many during baseline initiated free flow right turns on red.
- That eliminating permissive left turns reduces conflicts between pedestrians and left turning vehicles. It was also learned that many pedestrians attempt to cross during the vehicle protected phase before and after the no permissive left turn treatment was introduced and some drivers violate the no left turn signal just after the end of the protected left turn phase. It is recommended that a lagging protected left turn condition be considered instead of leading protected left turn condition.
- That the "Turning vehicles yield to pedestrians " symbol sign appeared no more effective than the conventional test message sign.

6.1.4 Lessons Learned: Implementation

- Coordinating improvements with other agencies, especially FDOT was of critical importance to the success of this project. We were fortunate to have the full involvement of FDOT District 6 and Miami-Dade County senior staff.
- Developing and implementing a comprehensive pedestrian safety plan requires a long time frame. This project took over six years, including almost two years for planning, two years for design/procurement/approvals, and

two years for implementation and evaluation. However, this time frame was partly the result of several hurricanes that damaged equipment and lead to a long-term backlog in installation schedules because of the extent of the damage to the traffic infrastructure that needed to be repaired. We were also delayed getting as-built plans because of new Homeland Security requirements.

- It was critical having a dedicated and highly competent pedestrian bicycle coordinator who had good relationships with all members of the team and was able to serve as a catalyst in getting things done. This project would have been difficult to achieve without his support.
- There are a wide range of pedestrian safety countermeasures available that can be tailored to specific location characteristics. A package of such measures can reduce vehicle/pedestrian conflicts, increase driver yielding, and bring about other changes in driver and pedestrian behavior that were associated with crash reductions.
- Particularly cost-effective countermeasures appear to be: countdown pedestrian signals; push buttons that confirm the press; rectangular LED rapid flashing beacons; reducing minimum green time; advance stop lines; and the use of a lead pedestrian phase.
- Low-cost but effective measures have the advantages of quick implementation and the potential to draw support and funding for further improvements.

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